INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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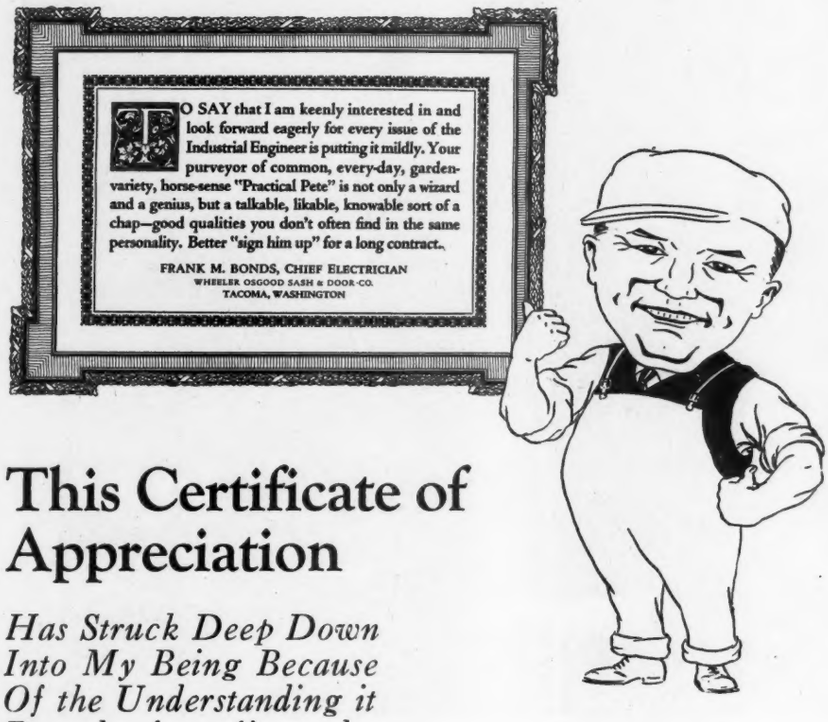

TO SAY that I am keenly interested in and look forward eagerly for every issue of the Industrial Engineer is putting it mildly. Your purveyor of common, every-day, garden-variety, horse-sense "Practical Pete" is not only a wizard and a genius, but a talkable, likable, knowable sort of a chap—good qualities you don't often find in the same personality. Better "sign him up" for a long contract.
FRANK M. BONDS, CHIEF ELECTRICIAN
WHEELER OSGOOD SASH & DOOR CO.
TACOMA, WASHINGTON

This Certificate of Appreciation

Has Struck Deep Down Into My Being Because Of the Understanding it Reveals of an Aim and a Purpose

DURING the past week we have all realized again the meaning of Christmas because we have seen the reaction of the mind of the child to the spirit of giving and all of us, whether we have known it or not, have experienced again the days of our childhood when the strife of this world of ours was an experience unknown and we expressed uncontrolled appreciation of the little things because they were a part of the spirit that is everywhere at Christmas time.

On December 24 I listened in through my radio headset to a sermon broadcasted from the Central Church of Chicago, which had for its theme the "Meaning of Christmas" and I took away two lessons that we can all learn. The first is that the spirit during Christmas time more than any other is a "Peace on Earth Among Men of Good Will." Peace not among jealous, ambition-aspiring and inwardly selfish men who see nothing good in the other fellow, but Peace among men of good will. The second is that although we have learned how to control and make use of almost all the physical forces of nature, we are totally ignorant of how to control and make use of the thing among men which expresses itself in good will.

And while I was listening in I heard a recital of this conversation between the head of a large corporation and a visitor who inquired how such a spirit of loyalty was created in his organization. The answer came when a call button was pushed by the executive and a young man walked in. To the question, "How long have you been with this company?" he answered, "Three years." Then he was asked, "Are you a stockholder?" and he replied with a smile of satisfaction, "I am." And finally he was asked, "How long do you expect to stay with us?" and the answer came without the least of hesitation, "I expect to stay with this company the rest of my life." Turning to his visitor, the executive of that company said: "You have heard from a boy with whom I have never talked before, the answer to your question—how we created loyalty in our organization. We don't create it; it grows from the fact that our men work with us, not for us, and we look for the opportunity to commend such spirit as this boy has displayed."

And so after twelve months of service with the readers and editors of this publication, I have selected from the many kind things that have been said, an expression from a reader who has not praised what I have furnished in way of usable information but an understanding of the spirit and the feeling I have tried to show in what I have written. He has found the key to good will among men that brings peace on earth and I am ready to say that I have a stock interest in the work of such men that will serve as an unwritten contract for my services with them and for them the rest of my life. Mr. Bonds, I thank you!

Practical Pete

A Glimpse Into the

Works of the U. S. Steel Corporation

This is the first of a series of short articles that will give a mental picture of the growth and extent of manufacturing works that form the backbone of this country's industrial activity.

An impression of the hugeness of a steel plant's operations is received from these blast furnaces of the Illinois Steel Company.

Below is the Homestead Works of the Carnegie Steel Company as it looked in 1890. It is now a part of the United States Steel Corporation.

INDUSTRIAL ENGINEER will present each month hereafter a series of pictures of the beginnings and present size and extent of those industrial works of this country on which some 290,000 manufacturing establishments depend for raw materials, supplies and machinery. These key industrial works stand as monuments of things accomplished by groups of men; department heads and their assistants, engineers and executives, whose importance ranks in this order. For on the successful execution of the work involved and the working out of the ideals and plans as a base, stand these monuments to broad vision and accomplish-

ments of the leaders in all our great works. Men close to the details of operations have made and are making these works what they are and they should be proud of the part they are taking in it, be it ever so humble.

THE United States Steel Corporation has been called a "genial giant." Its products form the backbone of many other American industries.

The story of the steel industry of America is dramatic. In 1845 the first blast furnace was built in this country and in 1881 there were only thirteen steel plants in America. Realizing this, we can appreciate the growth of this great corporation which now operates 142 plants and had a total output of over 14,000,000 tons of finished steel products in 1920. Going back again to the beginning of the iron and steel industry, we find that the first bar of iron was rolled in the United States in 1817. The first puddling furnace was installed in Boston in 1825. It was not, until 1845, however, as already mentioned, that the first blast furnace was put into use and in 1861 the first Bessemer converter was installed. In 1865 at the North Chicago plant of the Illinois Steel Company, now a part of the United States Steel Corporation, the first steel rail in America was rolled. The open-hearth furnace came in 1869.

It was after 1890 that the industry began its tremendous expansion. In 1901 two of the largest companies, the Illinois Steel and the Carnegie, combined and took in a number of other companies to form the United States Steel Corporation. Though the number of plants embraced in this corporation was practically the same as it is now (142 in 1922) the output in steel products in 1922 was almost double that in 1901. The number of blast furnaces has increased from 73 to 124. Moreover, the output of valuable by-products has increased enormously; for instance, cement from 162,000 bbl. to 12,500,000 bbl. and benzol from zero to 45,000,000 bbl. It is true also that the price of steel per ton actually decreased until the war period although most other products increased in price.

At the present time the United States Steel Corporation operates 142 plants that produce steel products and cement, sixteen subsidiary companies, sixty-five coke plants, sixty separate coal mines, ninety-six ore properties, one hundred and twenty-three steamships and three hundred and thirty other vessels, eight railroads with almost 1,000 miles of main line, besides dock, water-supply systems, gas and oil properties.

From one end of the rail mill above to the other is about as far as the eye can see.

This railroad yard of the Illinois Steel Company covers an area as large as a small city.

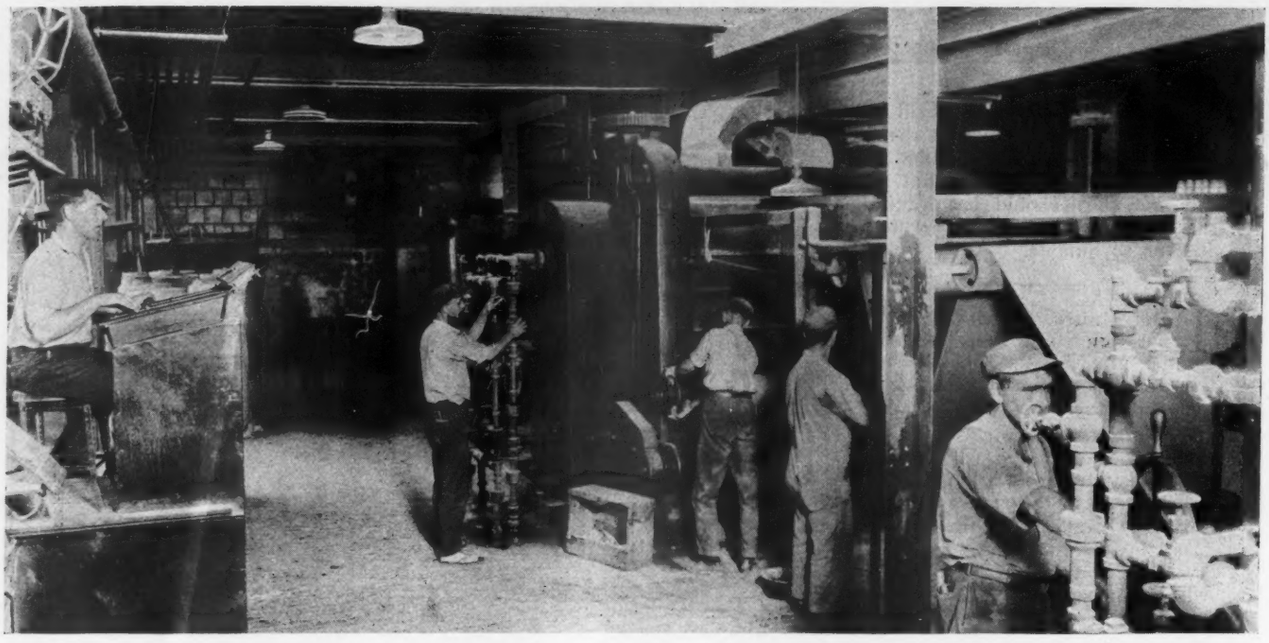


Fig. 1—Here three calender mills are operated as one mill. The speed of the individual motors is controlled (see Figs. 9 and 10) by the man at the desk through three sets of push buttons.

Some Details in The Application of a

Bonus on Operation and Maintenance

Whereby Foremen Are Rewarded According to Economies They Can Show in Maintenance and Power Costs

By A. A. FRANK

Factory Manager, The Federal Rubber Company, Racine, Wis.

ALTHOUGH FOREMEN and others in charge of shop operations are expected to give full attention to all details of supervision in their departments, human nature is such that there is a tendency to stop at "good enough" when a certain degree of achievement is attained, unless there is some incentive to do better. Comparatively few supervisors can drive themselves to do their best at all times. These few are most often found in the higher executive positions such as assistant superintendent, superintendent, president or some of the other members of the organization who carry the responsibility for production.

In general, there are three methods of getting a foreman (or a workman either) to do his best: (a) By driving; (b) by appealing to his pride or prejudices, his likes and dislikes; and, (c) by giving him a financial incentive, preferably graduated so as to increase with increased effort.

In the operation of these methods, men—foremen as well as workmen—resent driving. While they will do more for the "pat on the back" and the compliment of the second method, they often feel that they are not rewarded for the extra effort put forth while the company or the executive above them benefits from it. Usually the greatest satisfaction and best results come from sharing in some form of bonus, the additional profits or savings resulting from closer attention or effort. It is necessary, however, to fix the starting point on some definite standard or task and at an attainable figure so that the men are not discouraged by never earning a bonus. The reward should then increase as greater savings are made.

Rubber work, particularly the manufacture of automobile tires, lends itself to sufficient standardization to fix definite requirements or tasks as the basis of the bonus. In establishing the bonus plan at The Federal Rubber Company's plant, some of the following factors are used in determining the bonus basis

WHERE THERE is little incentive to do otherwise men are inclined to drift into a humdrum routine in handling the jobs assigned to them without doing much thinking. This is no criticism; it's human nature. Under the bonus plan, described in this article, the men in responsible positions are wide awake and think ahead because the extra money they can earn makes this worth while. The first year this plan was in operation in the works of The Federal Rubber Company at Racine, Wis., the total annual production cost was reduced 5 per cent.

Fig. 2—Bonus Standard in Electrical Department

For Class B Foreman

Item	Importance	First		Second		Third	
		Task	Bonus	Task	Bonus	Task	Bonus
Repair cost in factory per 1,000 lb. stock delivered from the mill room	45%	Standard*	$22.50	19% decrease	$45.00	38% decrease	$67.50
Total kw.-hr. per 1,000 lb. stock delivered from the mill room	25%	Standard*	12.50	15% decrease	25.00	30% decrease	37.50
Direct overhead of Electrical Dept.	10%	30%	5.00	25%	10.00	20%	15.00
Authorized labor — labor hours estimated on new installation	20%	100%	10.00	95%	20.00	90%	30.00
	100%		$50.00		$100.00		$150.00

*—Instead of actual figures this table calls the first task the "Standard" and then gives the percentage by which this standard must be decreased to make the second and third tasks. The foreman, however, knows the standard and also receives a report showing the record for the three months period.

Fig. 2—A sample task and bonus as applied to the foreman of the Electrical Department.

Similar standards are worked out for other foremen on bonus. This shows what the foreman must do—his task—and what he will earn—his bonus—by doing it. He is paid according to his accomplishments and may earn third bonus on some of the four items and a lower one or even fail on others.

for the foremen and assistant foremen. The bonus for *Production Departments* is based on a different set of factors than is used in determining the *Maintenance Departments'* bonus. The seven factors are:

1. Percentage of "seconds" and rejections.
2. Cost of repairs to imperfect products.
3. Percentage of waste per unit.
4. Departmental unit cost of production.
5. Materials consumed, based on production.
6. Amount of power used per unit.
7. Direct overhead costs.

In establishing this bonus two factors incidental to the industry help to establish the basis of the task. These are: (1) The cost of material is approximately 65 per cent of the cost of the finished product. (2) One definite unit, the amount in thousands of pounds of rubber stock delivered from the *Mill Room* governs the fluctuation of activity in practically all the other departments. The first factor is of principal importance in all manufacturing departments where the big savings lie in the decrease of waste fabric or rubber and in a reduction in the percentage of "seconds," of rejections and in the cost of repairs necessary to make imperfect products usable as a low grade.

The trimmed waste in each department is weighed up each night and charged against the department. It should not exceed a certain amount and is generally specified as a definite number of ounces allowed per tire or a certain percentage by weight of rubber or fabric handled. The bonus depends upon the amount of the reduction below this allowance. The other factor, the output from the *Mill Room*, is used as a basis for determining the amount of power which should be used and the bonus for the repair and maintenance work—factors which fluctuate according to the activity of the whole plant. Every 1,000 lb. of rubber stock going through the mill room means a fairly definite amount of work and power consumed in each succeeding department.

Tasks and Bonus in Electrical Department

To provide an incentive for increased effort, the bonus is graduated into first, second and third tasks, with a definite standard and bonus payment set for each. The three tasks and the bonus payments for each which may be earned by the foreman of the *Electrical Department*, are given in the accompanying table, Fig. 2. One feature of this bonus plan is that a foreman can earn what he accomplishes in each of the separate tasks. That is, he may earn third bonus in some items making up the bonus, while in others he makes lower tasks or even no task. The bonus is computed on his standing over a period of three months and, as shown in this table, will enable the foreman of the *Electrical Department* to earn $150 extra every three months providing he can make third task in each of the four items determining his bonus. He may make as low as $5 or even nothing.

The first item, "Repair cost in factory per 1,000 lb. stock delivered from the *Mill Room*," is considered as of 45 per cent importance in determining the bonus. This item includes the total cost of upkeep and repairs of machines and equipment and the expense of lubrication. All repair costs are grouped together for ease in computations even though the *Electrical Department* is responsible for only part of them. The same is true of other departments, mentioned later in this article, which base their bonus upon repair costs. This helps in making each department do its full share as it knows that its earnings depend upon the

								REMARKS
No.	798	Bldg.	11			Floor	Basement	
H.P.	100	Volts	115/230	Amps.	556	R.P.M.	237/950	Adjustable Speed
Serial	1951991			Type		SK		
Make	Westinghouse Electric Mfg. Co.							
Size of Brushes	5/8"x 1-1/2" x 2"							
No. of Brushes	18							
Size of Shaft				Size of Key				
Size of Pulley F.				D.				
Kind of Pulley								
Type of Controller	3 Wire D. C. Push button							
Make of Controller	Westinghouse							
Driving	#796 calender							

Fig. 3—Each motor has a record card similar to this.

Whenever possible the equipment number and location of other motors which may be substituted for a particular motor are noted on the back of the card. Often a motor can be taken from an idle or less essential machine in an emergency when no substitutes are on hand.

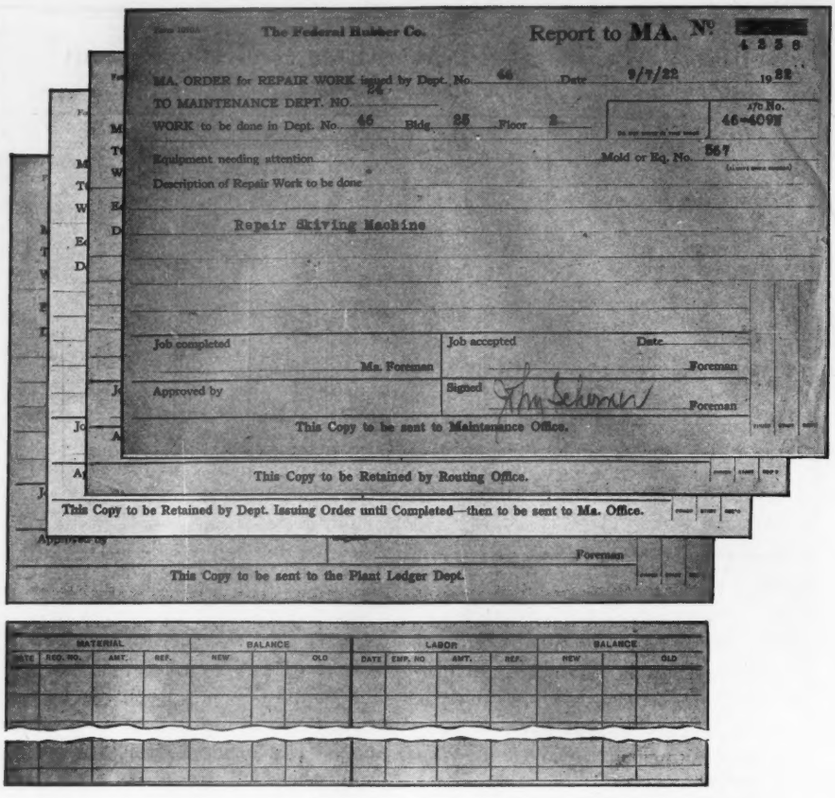


Fig. 4—How ordinary repairs or maintenance work is ordered and the labor costs gathered.

Copies of MA (maintenance) orders are made out in quadruplicate by the department where work is to be done. All copies are sent to the MA department, where they are numbered consecutively as they come in. The pink, or fourth copy, which is on a light card, is sent to the Plant Ledger Department for record and on the back of it is then posted the labor and material so that when the entire job is done the cost of the job is permanently recorded. The back of this card is shown broken. The white or third copy is returned to the originating department for its record. The blue (second) and yellow (original) copies are kept in the MA department until the work is completed. The number of hours on the job are entered on the back of the yellow copy and when the work is done this copy is sent to the foreman of the department where the order was issued, for his approval. Any question can then be taken up with the MA department at once. If O. K., the foreman signs on the line indicated "Job Accepted." It is then returned to the MA department which in turn sends it to the Plant Ledger Department. This is the final closing. The white copy is kept in the MA department files with any notations the Maintenance Department may desire to keep entered on the back. These are analyzed periodically as explained in the article.

efforts of all and that one department cannot save by shirking a little and forcing another department to do some of its work. Also each looks out for the other; an electrician will report a warm bearing or an oiler a sparking motor. Grouping of tasks thus practically forces the different departments to work together.

The second item, "Total kw.-hr. per 1,000 lb. stock delivered from the *Mill Room*" is rated as of 25 per cent importance in determining the bonus for this department. The *Electrical Department* foreman, while he has no direct supervision of the operation of the machines and motors in the various *Production Departments*, is responsible for the proper application of a motor and also for the inspection and upkeep of the various motors in all departments. If a motor is over- or underloaded it is up to his department to find it out and remedy it.

On the large motors, as in the *Mill Rooms* where approximately 90 per cent of the power is used, the mills are run idle at least once in each three months to see if the friction loss of the equipment is increasing. Here five or six mills (Fig. 11) are driven through gearing from pinions on a long shaft which in turn is connected through a reduction gear to a 400 or 500 hp., 2,300-volt motor. There are no clutches in the line and so all machines in the group are operating whether loaded or running idle. This grouping permits the motor to take care of any fluctuations in the load which might give a momentarily heavy overload if each mill had its own drive. The friction loss on these mills is of great importance as even under the best conditions the mills when running idle use about half the power consumed when running loaded. Any increase in this friction loss adds considerably to the power consumption. An indicating ammeter mounted on the motor control-board in the basement (Fig. 12) shows the fluctuation in power as the mill is operating and by observation the electrician can usually spot any unusual increase in total consumption without making the no-load tests. This gives him a quick indication that something is wrong.

In addition, the electrical department changes brushes and periodically cleans the motors and switchboards which become covered with the powdered soapstone used in the milling process. In the *Mill Rooms* this is blown out each Sunday when the equipment is "dead," as the compressed air contains too much moisture to risk using on 2,300 volt equipment when it is "alive." One electrician and his helper work nights. The helper cleans and oils and the electrician makes necessary repairs on day motors and any emergency night repairs.

Any reduction in the direct overhead of the department, the third item determining the bonus, is largely on the responsibility of the foreman and is rated at 10 per cent in importance. Overhead is figured on direct labor. Its reduction is largely a matter of supervision.

"Authorized labor," the fourth item, is the labor applied in the construction or erection of any new or permanent work such as a new lighting system or the wiring for a new motor. Any work which will cost more than $100 must be authorized by some official and a careful estimate made of the cost and the results expected before it can be started. This authorization report is made out as shown in Fig. 5. If the foremen (most jobs costing over $100 involve more than one *Maintenance Department*) keep within the estimate they earn the first bonus; if they go below 95 per cent, they earn the second bonus; and, if below 90 per cent, or 10 per cent saved, the third bonus. The workmen in the various maintenance and repair gangs share in this by earning as a bonus pay for one-half of the hours saved in addition to their regular wages.

In determining whether or not a bonus is made on authorized labor, the labor-hours are not subdivided and credited against the separate *Maintenance Departments*, if two or more are involved on any job, but the net result is used as a basis. Thus one department may have

gained but if the others lose more than was gained only the net result is used. The bonus is determined according to the net standing over a three-months' period instead of by individual jobs. This plan of grouping also tends to make all departments and gangs work together since they have a common purpose.

Bonus Plans in Other Maintenance Departments

Other department foremen, besides those engaged in production, who receive a bonus are the foremen of the *Pipe Shop, Machine Shop* (outside maintenance work) and *Machine Shop* (inside shop work), the general foreman over both *Machine Shop* foremen, the foremen over *Maintenance Inspection* in charge of oiling, etc., and *Carpenter and Box Shop*, and the general foreman and day and night foremen of the *Power Department*. In addition, the superintendent of maintenance, who has charge of all except the *Power Department*, receives a bonus which is based upon the bonus earned by the departments under his direction. He also has supervision over the yards and sewers but the foreman on this work, however, is not on a bonus.

All foremen are rated or classed according to their importance; the superintendent of maintenance is a Class AA man, the general foremen of *Power* and of the *Machine Shops* are Class A men, the foremen are Class B men, and the assistant foremen are classified as Class C or D men. Generally the bonus in each class is 75 to 80 per cent of the bonus of the next class higher.

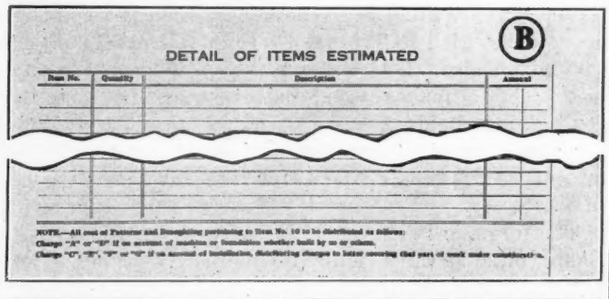
It will be interesting to go over the items making up the bonus in some of these departments and see how their work is closely related to the selection of the items. For example in the *Pipe Shop*, which does all new and maintenance work on the steam, water and air lines, the kilowatt-hours used are not taken into consideration as work of this department does not affect this item. Here three points are considered which, with their importance, are as follows:

1. Repair cost per 1,000 lb. from Mill Room....50 per cent
2. Department overhead....20 " "
3. Authorized labor.....30 " "

These three items are used also in determining the bonus of the foreman of the *Machine Shop* (inside shop work) and of the *Box and Carpenter Shop*. As each of these two has inside work where closer supervision may be given to the overhead and they are still less closely connected with the responsibility for outside maintenance, the importance of the three items is changed to a new ratio of 45, 25 and 30 per cent. A large share of the work in this *Machine Shop* consists of building and repairing tire molds and cores

Fig. 5—Requisition for additions and extensive alterations or repairs.

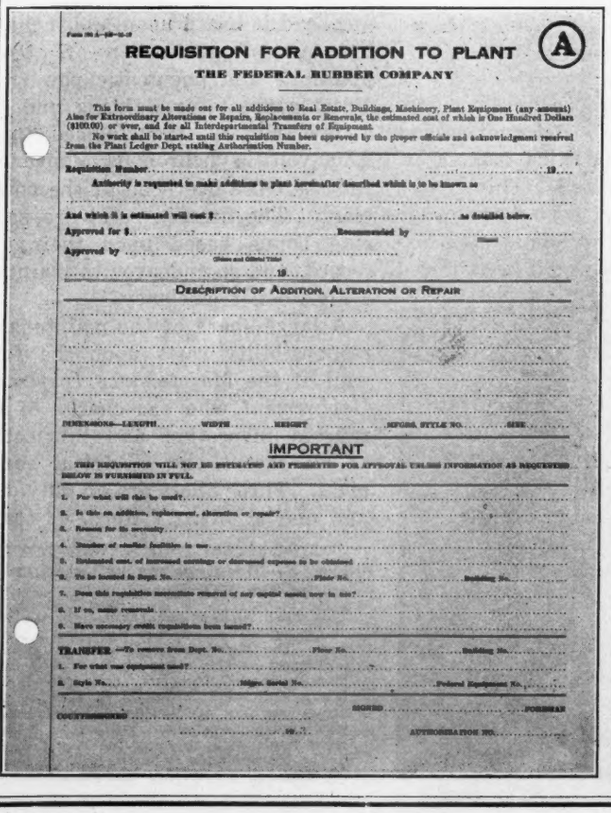
All additions to the plant, machinery or equipment, and extraordinary alterations, replacements or renewals, which it is estimated will cost over $100, as well as interdepartmental transfers of equipment, are requisitioned on this form. It is then approved and authorized by some official of the company before work can be started. The labor involved is called "authorized labor" (Fig. 2) and is one item in determining the bonus of Maintenance Department foremen who have responsibility for construction and maintenance work. On the second page (B) is a detailed list of materials for the job. The fourth page is blank for sketches or additional entries. When costs of new work are carefully estimated in advance there is less likelihood of making an unwise move. Departments receive this bonus on the reductions of "estimated" hours of labor by the group of Maintenance Departments.


B

DETAIL OF ITEMS ESTIMATED

Item No. | Quantity | Description | Amount

NOTE.—All cost of Patterns and Draughting pertaining to Item No. 10 to be distributed as follows:
Charge "A" or "D" if on account of machine or foundation whether built by us or others.
Charge "C", "E", "F" or "G" if on account of installation, distributing charges to letter covering that part of work under consideration.


A

REQUISITION FOR ADDITION TO PLANT

THE FEDERAL RUBBER COMPANY

This form must be made out for all additions to Real Estate, Buildings, Machinery, Plant Equipment (any amount) Also for Extraordinary Alterations or Repairs, Replacements or Renewals, the estimated cost of which is One Hundred Dollars ($100.00) or over, and for all Interdepartmental Transfers of Equipment.

No work shall be started until this requisition has been approved by the proper officials and acknowledgment received from the Plant Ledger Dept. stating Authorization Number.

Requisition Number ..... 19....

Authority is requested to make additions to plant hereinafter described which is to be known as

.....

And which it is estimated will cost $..... as detailed below.

Approved for $..... Recommended by .....

Approved by .....

(Name and Official Title)

..... 19....

DESCRIPTION OF ADDITION, ALTERATION OR REPAIR

DIMENSIONS—LENGTH ..... WIDTH ..... HEIGHT ..... SPEED, STYLE NO. ..... SIZE .....

IMPORTANT

THIS REQUISITION WILL NOT BE ESTIMATED AND PRESENTED FOR APPROVAL UNLESS INFORMATION AS REQUESTED BELOW IS FURNISHED IN FULL.

1. For what will this be used?.....
2. Is this an addition, replacement, alteration or repair?.....
3. Reason for its necessity.....
4. Number of similar facilities in use.....
5. Estimated amt. of increased earnings or decreased expense to be obtained .....
6. To be located in Dept. No. ..... Floor No. ..... Building No. .....
7. Does this requisition necessitate removal of any capital assets now in use?.....
8. If so, name removals .....
9. Have necessary credit requisitions been issued?.....

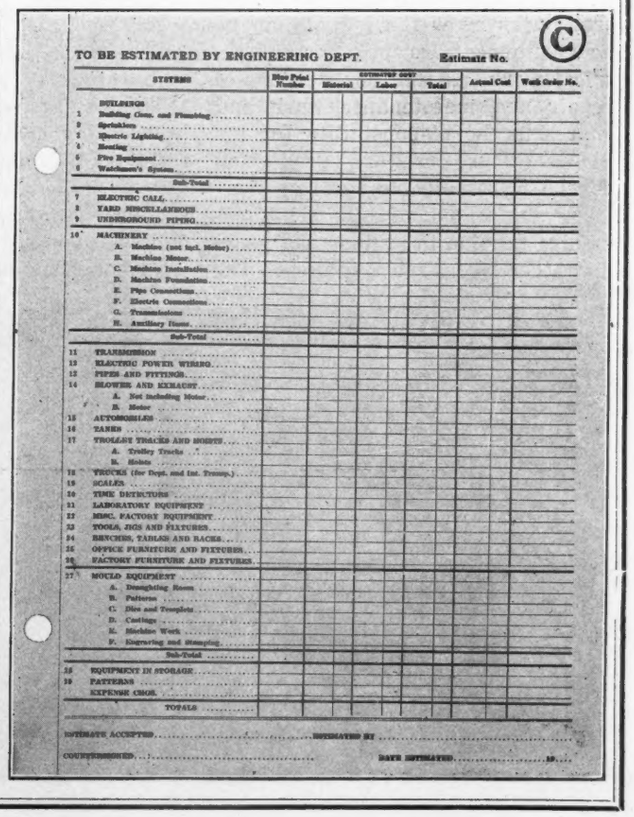
TRANSFER.—To remove from Dept. No. ..... Floor No. ..... Building No. .....

1. For what use equipment used?.....
2. Style No. ..... Mfgrs. Serial No. ..... Federal Equipment No. .....

SIGNED ..... FOREMAN

COUNTERSIGNED .....

..... 19.... AUTHORIZATION NO. .....


C

TO BE ESTIMATED BY ENGINEERING DEPT. Estimate No.

	STATIONS	Blue Print Number	ESTIMATED COST Material	Labor	Total	Actual Cost	Work Order No.
	BUILDINGS						
1	Building Const. and Plumbing						
2	Sprinklers						
3	Electric Lighting						
4	Heating						
5	Fire Equipment						
6	Watchmen's System						
	Sub-Total						
7	ELECTRIC CELL						
8	YARD MISCELLANEOUS						
9	UNDERGROUND PIPING						
10	MACHINERY						
	A. Machine (not incl. Motor)						
	B. Machine Motor						
	C. Machine Installation						
	D. Machine Foundation						
	E. Pipe Connections						
	F. Electric Connections						
	G. Transmissions						
	H. Ancillary Items						
	Sub-Total						
11	TRANSMISSION						
13	ELECTRIC POWER WIRING						
12	PIPES AND FITTINGS						
14	BLOWERS AND EXHAUST						
	A. Not Including Motor						
	B. Motor						
15	AUTOMOBILES						
16	TAXES						
17	TROLLEY TRACKS AND HOISTS						
	A. Trolley Tracks						
	B. Hoists						
18	TRUCKS (for Dept. and Int. Transp.)						
19	SCALES						
20	TIME DETECTORS						
21	LABORATORY EQUIPMENT						
22	MISC. FACTORY EQUIPMENT						
23	TOOLS, JIGS AND FIXTURES						
24	BENCHES, TABLES AND RACKS						
25	OFFICE FURNITURE AND FIXTURES						
26	FACTORY FURNITURE AND FIXTURES						
27	MOULD EQUIPMENT						
	A. Draughting Room						
	B. Patterns						
	C. Dies and Templets						
	D. Castings						
	E. Machine Work						
	F. Engraving and Stamping						
	Sub-Total						
28	EQUIPMENT IN STORAGE						
29	PATTERNS						
	EXPENSE CHGS.						
	TOTALS						

ESTIMATE ACCEPTED ..... ESTIMATED BY .....

COUNTERSIGNED ..... DATE ESTIMATED ..... 19....

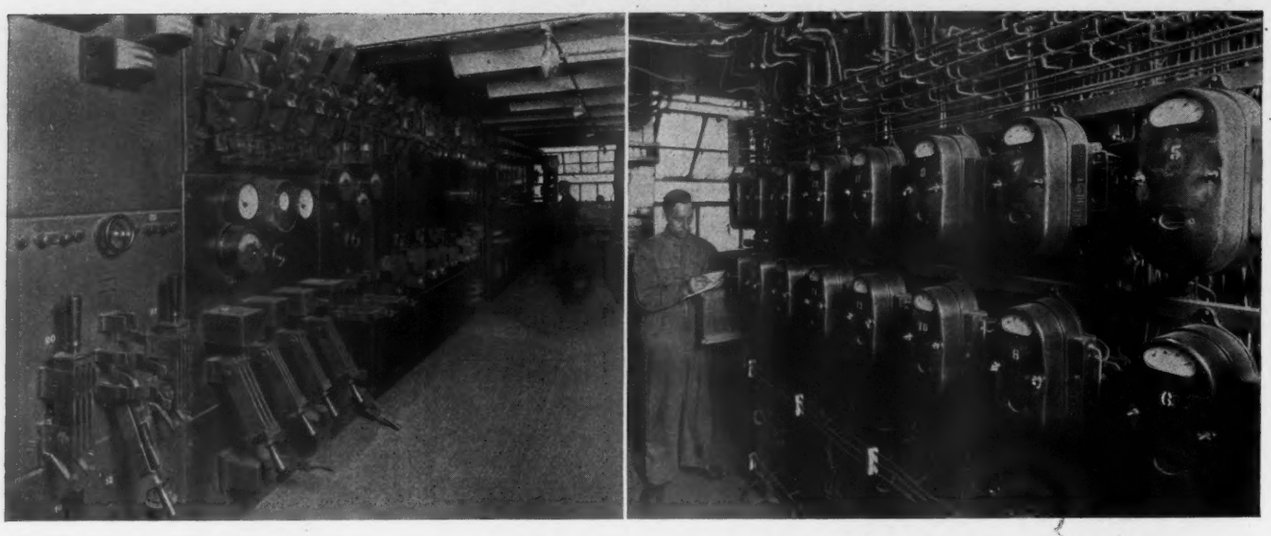


Fig. 6—Main switchboard in Power Department.

At present electrical energy is purchased but the generating equipment is retained for emergency service. The section at the far end contains the meters for the individual Production Departments.

for production processes although any necessary maintenance construction, rebuilding of machines, or new work which it is fitted to do is carried on also. The *Box and Carpenter Shop* makes wood patterns for casting molds and cores, boxes for exporting tires and any cabinet or carpenter repair work for the plant.

The foreman in charge of *Machine Shop* (outside work, which is more strictly plant maintenance), however, looks after the installation of new equipment, except pipe and electrical work, as well as the general repair and maintenance work and shares in the responsibility for the kilowatt-hours used in production for he is responsible for bad bearings, shafts out of alignment, excessive friction in pinions and gears and other heavy friction losses. The items in his bonus and their importance are the same as given in Fig. 2 for the *Electrical Department* foreman.

Power Department Bonus Based on Boiler Efficiency

Neither the kilowatt-hours used nor the cost of repairs has any influence upon the *Power Department* bonus. Electric energy is purchased and metered (Figs. 6 and 7), to each production department. These meter readings, however, are recorded by the *Power Department*. The items here are:

1. Power department labor hours per ton of coal used .....20 per cent
2. Over-all monthly boiler efficiency .....70 " "
3. Direct department overhead .....10 " "

The labor allowance for first task in handling coal is 1.4 hr.; second task, 1.2 hr.; and, third task, 1 hr. per ton of coal used. This covers the labor from car to bunker storage and the handling of the ashes. Extra labor, such as would be required for moving coal to and from yard storage, is not included. The first task in boiler efficiency is to maintain an over-all efficiency of 64 per cent, the second task an efficiency of 67 per cent and a third task of 70 per cent. The average efficiency over the entire month is used to determine the percentage of attainment instead of taking results of irregular or periodic tests. The departmental overhead is based upon and includes the cost of generation of steam, hydraulic and pneumatic power, of direct current for lighting and for a few motors, transformed by a 2,300-volt synchronous converter, and the office overhead of the power plant. The firemen receive a separate bonus based upon their CO_2 record, and so endeavor to maintain a high boiler efficiency.

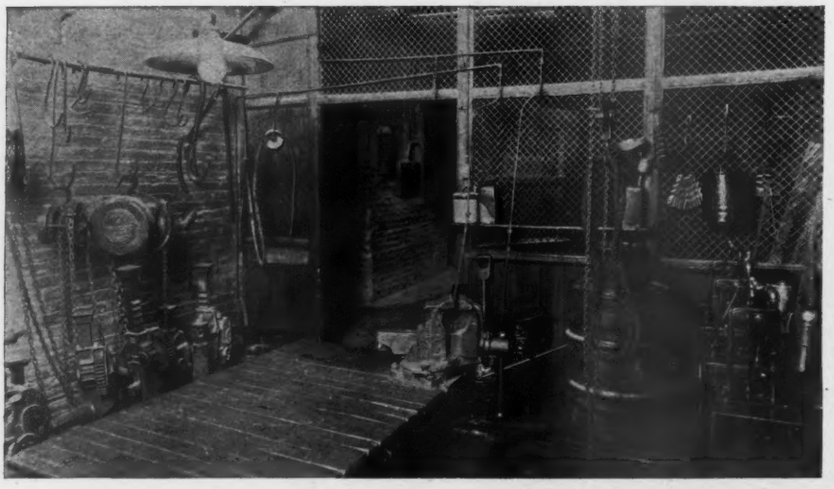


Fig. 7—Power consumption of each department is recorded here.

These D-6 General Electric polyphase integrating meters placed on the back of the switchboard are read by the Power Department periodically. Without some means of knowing the power consumed in each department, this organization would not have such careful supervisory control over the production costs nor could it operate the bonus plan as described in this article.

A large share of the maintenance responsibility rests upon the foreman of the *Maintenance Inspection Department* who has charge of the routine inspection and lubrication of all except the electrical equipment. Three oilers are on duty days and one at night. Here, as stated

Fig. 8—Maintenance sub-station in one of the Mill Rooms.

This small room is separated from the rest of the department by fire walls and a stairway. The Maintenance Department, which is located at the other side of the plant, stores many of its hoists, jacks and similar heavy equipment where it is close to the heavy machine installations. A bench and vise enable many small repairs or fittings to be made without going the long distance to the Maintenance Department. The oilers fill their oil cans from the storage tanks.

previously, the men co-operate in reporting difficulties to each other as the bonus depends upon the efforts of the group instead of the individual. The items upon which the bonus is based and the relative importance of each are the same as for the *Electrical Department* foreman as given in the table, Fig. 2.

How the Bonus Is Applied to Production Departments

The foremen and some assistant foremen in the *Production Departments* are on a bonus also but the power consumed is a governing factor only in the *Mill Rooms* where it is based on standards set per 1,000 lb. of rubber stock out of each department. This factor varies with each of the different *Mill Rooms*—the *Main Mill Room* where the rubber stock is milled and calendered for the automobile tires; the *Baby Cab Department*, where solid tires are made for baby cabs, velocipedes, etc.; the *Mixed and Green Scrap Department* where the preliminary working and mixing is done; and, the *Shoddy and Scrap Department* where reclaimed rubber is mixed with scrap and new rubber to be used for making floor mats and similar products which do not require as high-grade rubber stock as tires. Each of these departments is of a different capacity and so each has its own task of standard kilowatt-hour used per 1,000 lb. of stock delivered. These departments, however, are the largest users of power, taking about 90 per cent of all the power used in the plant.

The other items affecting the bonus of the *Milling Departments*, in addition to the kilowatt-hours used, are: Direct overhead and labor costs per unit of production. In the *Milling Departments* the unit is per 1,000 lb. stock delivered. As such a large percentage of the power is used in overcoming the friction of the mills and their heavy gearing, the *Mill Room* foremen's opportunity to save on power, and so earn their bonus, is to see that the mills are loaded as much of the time as possible, and if it is necessary that some be idle to see that the idle mills are all on one group so that the motor of that group may be shut down. Otherwise the whole group of five mills will continue the heavy friction loss even if only one mill is in use.

The other *Production Departments* do not have their bonus based on power used as it is only a small item with them. The large items are waste, "seconds," direct labor and overhead, so the bonus here is placed on such items as:

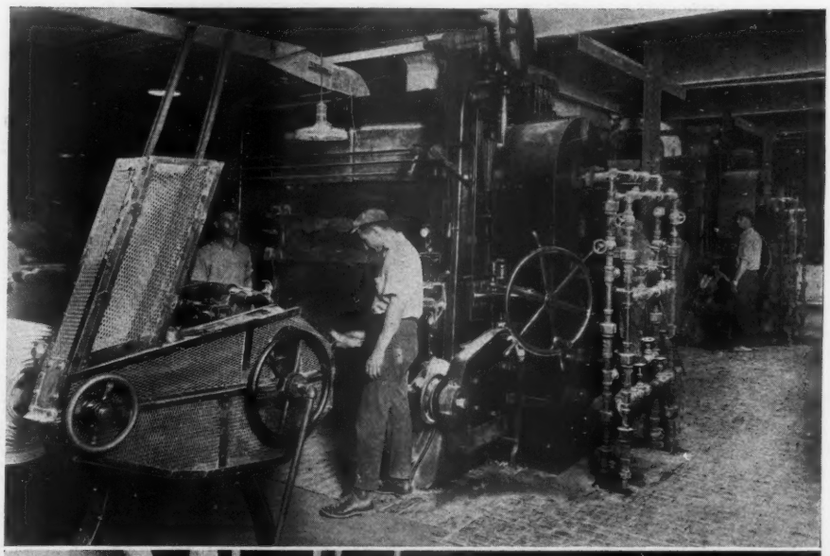
1. Waste per unit manufactured.
2. Percentage of "seconds" or rejections.
3. Direct labor per unit.
4. Departmental overhead.

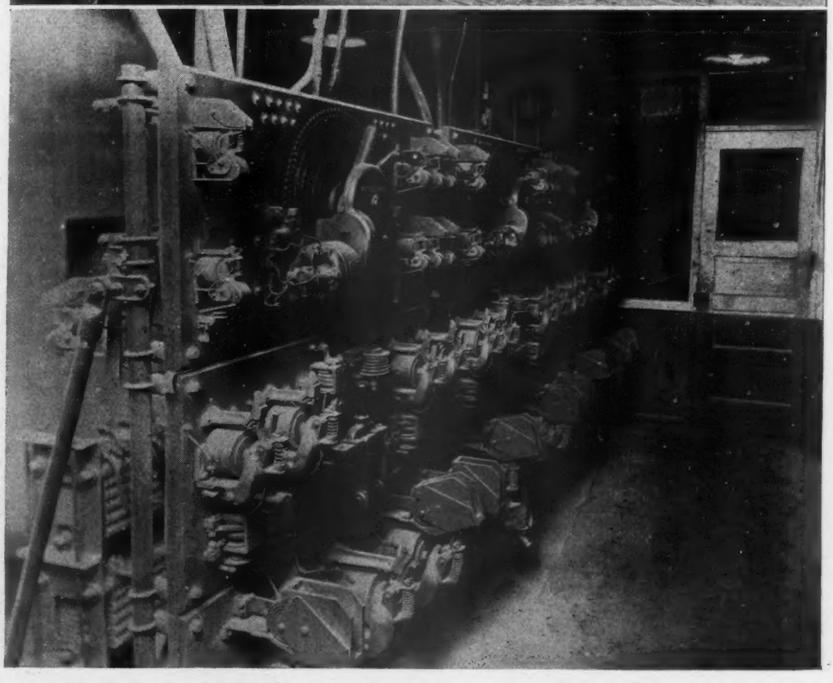
The percentage of importance of each varies somewhat in the different departments, according to the conditions. The waste or trimmings of each operator is collected and weighed each night. As a result the operators are more careful to cut fabric to the right length and use up short lengths of rubber stock.

The workers in the production departments do not have a bonus but work on straight piece work. The inspectors in the *Pneumatic Division*, however, who are wage earners, work on a monthly bonus similar to and with the same factors as the bonus for foremen in that division.

Where Emphasis Must Be Placed in a Maintenance Bonus

In a bonus of this kind on maintenance one point must be kept in mind and impressed thoroughly in





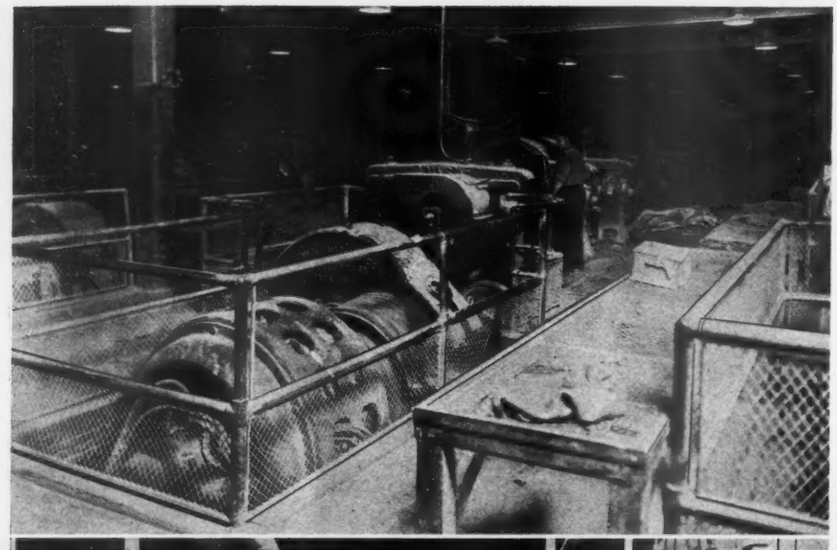
Figs. 9 and 10—Another view of the three calender mills (Fig. 1) and their control mechanism.

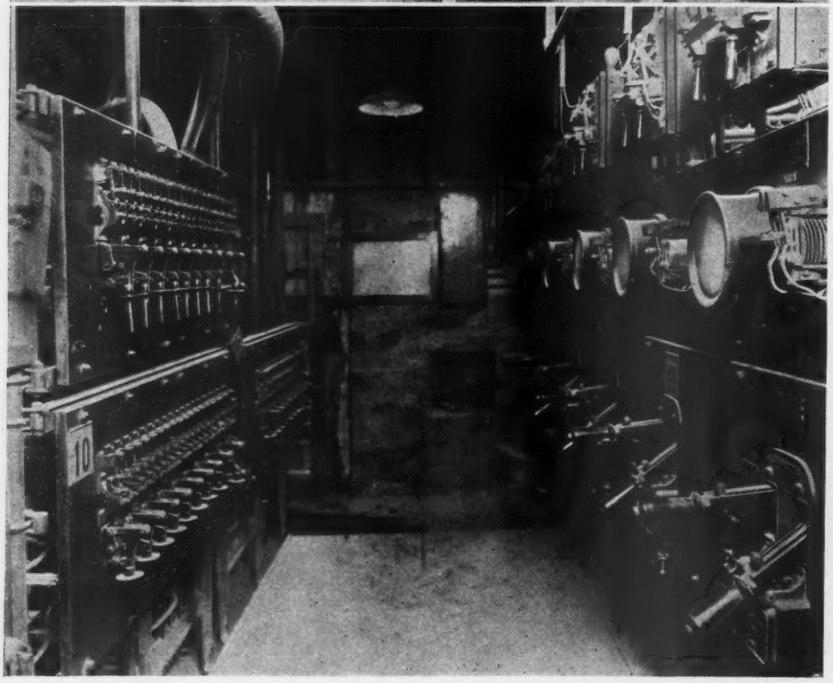
To be able to start up slowly and gradually build up to full speed the motor on each mill has adjustable speed control obtained through the motor-operated field rheostat accelerated by Type C Westinghouse control. As the operator at the desk (Fig. 1) pushes the "increase" or "decrease" button the small motor advances or moves back the rheostat contact arm as long as his finger is on the button. In this way the three machines are brought up to uniform speed when operating as one unit. Weekly inspections and immediate replacement of all worn parts reduce the shut-downs for repairs to a minimum.

the minds of the different foremen; namely, that nothing is to be gained by skimping on maintenance costs. A big saving through skimping during one three-month bonus period may eliminate all possibility of a bonus for several periods afterward, because repairs put off or half done are then twice or sometimes three times as expensive as they should be. Any savings from doing a poor job are slight, especially when divided among all the jobs during a three months' period. Rather, it is better in the end, from both bonus and company standpoints, to do a little extra if it will decrease repair costs in the future. One example shows how this is working out. In one of the departments several different makes of motors are used although all are of the same horsepower. The result is that there is but little flexibility because the motors are not interchangeable on the different bases and often a motor must be "petted" along to keep it going until repairs can be made out of hours on overtime. Now, whenever it is necessary to take one of these motors down for repairs, the base is made standard at a slight additional expense above the necessary repairs so that the next time it gets out of order a substitute motor can be put in its place in a few minutes and the motor repaired in the shop at a minimum of expense.

For the same reason bearings are lengthened when they burn out too often, parts are re-designed and strengthened when they break too frequently, and many other changes are made toward reducing repair and maintenance costs in the future, even though they are slightly increased on any one job.

One place which requires weekly inspection is the adjustable speed motor control system (Fig. 10) for three calender mills (Figs. 1 and 9), which are used for impregnating the fabric with rubber. These three mills are placed in line and may be operated individually or in a group with the work passing in one continuous line through and operated on by all three machines. Each machine is driven by its individual 100-hp. motor. To get adjustable speed control, 440-volt direct current is used. These, by the way, are the only direct-current motors of any size used. A push-button control at each mill puts the motor under control of the operator when each calender is operated individually. The control mechanism (Fig. 10) is located in the basement, under the group of calenders. When the three mills are operated as a group the speed and operation for each of the three machines is controlled through a set of push-buttons by the man at the desk shown at the left in Fig. 1. He speeds up or decreases the speed of any of the three mills as necessary to keep them operating uniformly. Each of the three individual sets of push-buttons at his desk are marked: "Start," "Stop," "Reverse," "Slow," "Fast," "Increase," "Decrease" and "Inch." The minimum speed of these 100-hp. motors is 40 per cent of the maximum speed. The contact points in the control are burned by the frequent changes in speed and at the weekly inspection are scraped or renewed whenever they show any wear.



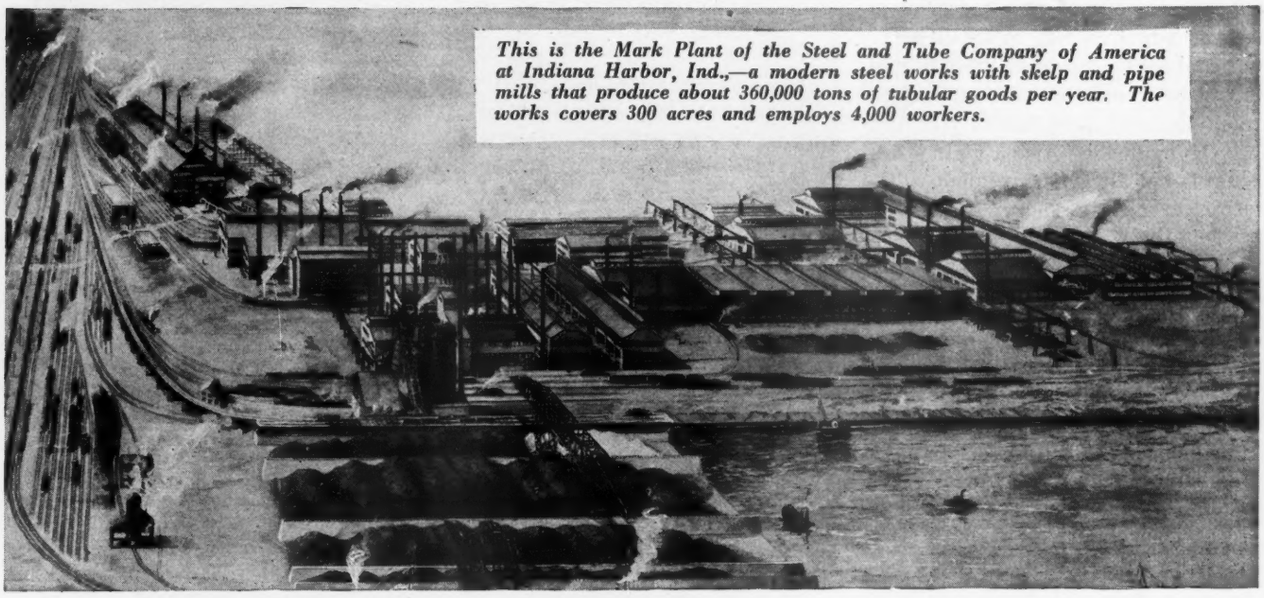


Figs. 11 and 12—One of the mill motor units and its control mechanism.

Groups of five or six rubber mills are driven from pinions on a long shaft which in turn is connected through a reduction gear to 400- or 500-hp., 2,300-volt, 60-cycle, 3-phase motors. The control mechanism is placed in the basement, as shown at the left. The equipment for the motor of each group of machines is numbered conspicuously. The door to this room is left unlocked so that anyone responsible can easily get into it in an emergency. The panels at the left carry Cutler-Hammer multiple switch starters. At the right, indicating ammeters are placed on the center panel with Westinghouse Type F oil breakers, manually operated, at the bottom and Cutler-Hammer overload circuit breakers at the top.

Equipment Records Kept

The record card, Fig. 3, is kept by the *Electrical Department* for each motor in the plant. On the back of this record is entered the number and location (*Continued on page* 67)



This is the Mark Plant of the Steel and Tube Company of America at Indiana Harbor, Ind.,—a modern steel works with skelp and pipe mills that produce about 360,000 tons of tubular goods per year. The works covers 300 acres and employs 4,000 workers.

Some of the Ways

Procedure in Maintenance Work Can Be Audited

By the Maintenance Department to Improve Standards of Power Service

By ARTHUR J. WHITCOMB

Formerly Assistant to Superintendent, The Steel & Tube Company of America

AN AUDITING or accounting system is often looked upon as a necessary evil in the handling of a small business but as the departments of that business expand and competition becomes keen, the accounting system becomes more and more important and the auditor is looked to for information that will show the trend of operations from the standpoints of profits and losses.

Granting that these conditions hold true for all lines of business, why is it not logical to apply the accounting principle to operating and maintenance procedure in industrial works? Here as in any business certain expenditures are essential to the continuity of production and certain credits result from the maintenance of adequate operating service standards from the standpoint of continuity of operating processes. The factors that can be controlled are interruptions caused by preventable failures of machines from natural wear and tear, accidents and the like. Without definite information by which to measure or compare results of different service standards and balance expenditures against possible economies shown by continuity of operations or increases in quantity or quality of the product produced, the final audit of the business is no true indication of the degree of intelligence that is applied between the receipt and expenditure of the moneys that an audit will show.

THIS IS THE FIRST of four articles that will analyze the essential factors of maintenance procedure. It takes up a method of handling repair and replacement materials, to show the need, storing and use of same. Some of the points covered are: How the storekeeper keeps track of his stock; how he knows what and when to reorder; how requisitions are approved and materials drawn from stock; how invoices are passed for payment; how charges are made to departments using the materials. The second article will take up an accounting of power service; the third an accounting of the work of the electrical department; how charges are made to counting of electrical equipment used in production processes.

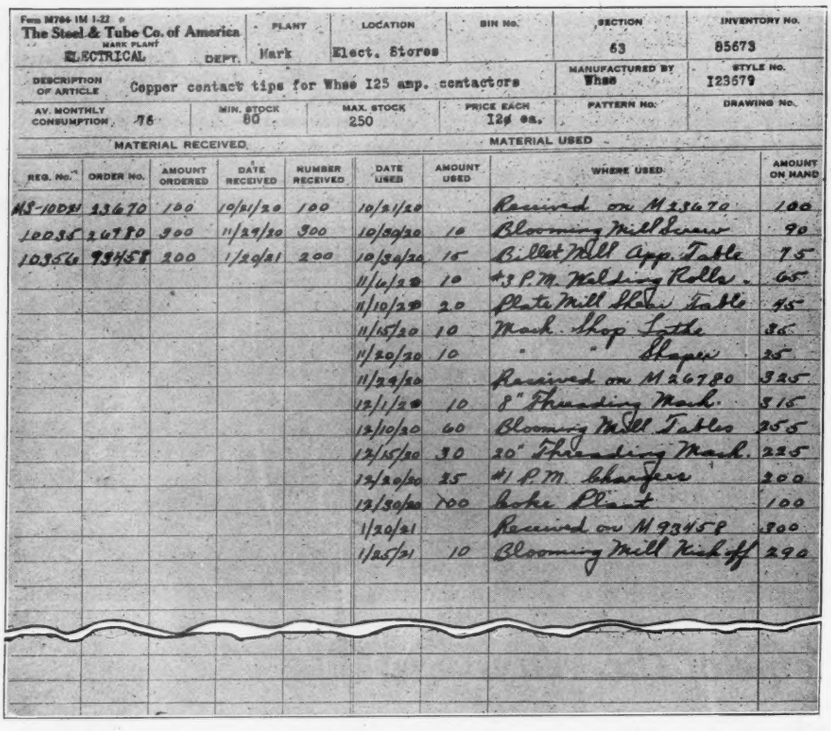
The purpose of this article and others that will follow it, is to show how an audit may be made of the operations of a maintenance department before and at the time the expenditures are being created by that department. This method will include: (1) A means of auditing the incoming and outgoing electrical material, such as repairs, spare parts, etc. (2) A power service audit; that is, a power distribution. (3) An accounting of the work of the men in the electrical department. (4) An accounting or record of electrical equipment.

In this article a method of accounting for electrical material in the maintenance of power service in a large works will be discussed.

One of the first necessities of the auditor is a safe. The first necessity in accounting for material is a storeroom in which all maintenance materials may be stored. This storeroom should have a central location and should be adjacent to the electrical repair shop. The storeroom is controlled by a storekeeper who is charged with the receipt, storing and disbursement of material. He should have one or more assistants as needed.

In many plants electrical materials are kept in a main storeroom. Since electrical material is quite different from other material and consists of

a great variety of raw material as well as a multiplicity of small parts, not commonly known to most people, it will be found that ordinary storeroom help will have difficulty in finding the material. Also a main storeroom is not always convenient to the electrical repair shop. For these reasons the writer believes it is best to have the electrical storeroom a part of the electrical department and under the supervision of the electrical superintendent. This fixes the responsibility on one person and the electrical superintendent is better qualified to keep on hand the materials he needs to run his department. He should set up a system for requisitioning material as needed and his storekeeper should issue charge tickets for all material disbursed. Under this plan the main storeroom receives the material as it enters the plant, keeps a record of the receipts and passes it directly to the electrical department. The charge tickets for material disbursed will then go to the main storeroom for pricing and auditing. This work can be readily done at the main storeroom by a clerical force and it reduces the clerical work required in the electrical department.



Form M784-1M 1-22

The Steel & Tube Co. of America — MARK PLANT — ELECTRICAL DEPT. — PLANT: Mark — LOCATION: Elect. Stores — BIN NO. — SECTION: 63 — INVENTORY NO.: 85673

DESCRIPTION OF ARTICLE: Copper contact tips for Whse I25 amp. contactors — MANUFACTURED BY: Whse — STYLE NO.: 123679

AV. MONTHLY CONSUMPTION: 75 — MIN. STOCK: 60 — MAX. STOCK: 250 — PRICE EACH: I2¢ ea. — PATTERN NO. — DRAWING NO.

MATERIAL RECEIVED					MATERIAL USED			
REQ. NO.	ORDER NO.	AMOUNT ORDERED	DATE RECEIVED	NUMBER RECEIVED	DATE USED	AMOUNT USED	WHERE USED	AMOUNT ON HAND
MS-10091	23670	100	10/21/20	100	10/21/20		Received on M23670	100
10035	26780	300	11/29/20	300	10/30/20	10	Blooming Mill Crane	90
10356	93458	200	1/20/21	200	10/30/20	15	Billet Mill App. Table	75
					11/4/20	10	#3 P.M. Welding Rolls	65
					11/10/20	20	Plate Mill Shear Table	45
					11/15/20	10	Mach. Shop Lathe	35
					11/20/20	10	" Shaper	25
					11/24/20		Received on M26780	325
					12/1/20	10	8" Threading Mach.	315
					12/10/20	60	Blooming Mill Tables	255
					12/15/20	30	20" Threading Mach.	225
					12/20/20	25	#1 P.M. Shearfoot	200
					12/30/20	100	Boiler Plant	100
					1/20/21		Received on M93458	300
					1/25/21	10	Blooming Mill Kickoff	290

Fig. 1—The backbone of every accounting system is the ledger. Similarly the backbone of the stores accounting system of an industrial works is a ledger arranged in the form of a card system. The cards are known as inventory cards and a convenient form is shown above.

A Good Arrangement for a Storeroom

In the electrical storeroom a great many small parts are stored, hence the best arrangement is rows of steel bins arranged back to back and in tiers up from the floor. The bins should be of various sizes and for some articles steel drawers are convenient. Coils can be stored on shelves and wire and cable may be neatly arranged on reels. The smaller sizes of wire may be left on the spools and the spools placed on the shelves.

All bins, drawers, or shelves should have a card holder. On the card a brief description of the material is essential together with the manufacturer's style number, such as "Whse. S, No. 123679 Contact Tips for 125 Amp. Contactor." The inventory number of the material should also appear on this particular card.

The inventory number or bin number, as it is sometimes called, is a number assigned to a certain kind of material. Each different kind of material should have a different inventory number. This number definitely identifies the material, for each different material has a different inventory number as shown below:

Inventory Number	Description
85673	Whse. S, No. 123679 Contact Tips for 125-amp. contactor.
85674	Whse. S, No. 123680 Contact Tips for 250-amp. contactor.
85675	Whse. S, No. 123694 Contact Tips for 500-amp. contactor.

The backbone of every accounting system is the ledger. Similarly, the backbone of the stores accounting system is a ledger arranged in the form of a card system. These cards are known as inventory cards. A suitable form is shown in Fig. 1. At the top of it spaces are provided for proper identification. The remainder of it is divided into two parts, one side for material received and the other side for material used. One side is a debit, the other is a credit. In other words, the card is simply a double entry ledger.

In the upper right hand corner of the card is a space for the inventory number on the bin in which the material is stored. This number definitely identifies the material. To the left of the inventory number is a space for the section number which will be explained later. The next space is not used because the bin number is the same as the inventory number. The next three spaces are for location, plant and department.

On the second line is a space for the description of the article. This should be complete, for it is from this description that the material is reordered. The description should tell what the article is and if it is a special part it should show what it is used for. If it is raw material such as red fibre, mica, etc., it should give the size or dimensions. The space marked "Manufactured by" is to show where the material may be obtained. There is a space for the manufacturers' style number, drawing number, and pattern number. These are essential to a complete description. There is also a space for the price per unit of quantity. This provides a record of previous prices of the material in buying a new lot. This value should not be used for charging out the material on hand as will be explained later.

There are spaces for "average monthly consumption," "minimum stock," and "maximum stock." These are required in order to tell when and how much to reorder. When the amount on hand gets down to the minimum stock, it is time to reorder. The usual plan is to order enough to bring the stock up to maximum amount. However, if the delivery is likely to be slow, it is best to add an amount determined by the average monthly consumption to take care of probable delays in delivery.

On the "Material Received" side of the cards are columns for the requisition number, purchase number, amount ordered, date received and number received. On the "Material Used" side are the columns for the date used, amount used, where used, and amount on hand.

When material is ordered the number of the requisition and the amount ordered are placed on the "Material Received" side. When the material is received, the order number on which it was received, the date and the number received are placed in the remaining columns on this side. Also on the "Material Used" side an entry is made "Received on Order M....." and the amount received is added to the amount previously on hand. As disbursements are made, the date, amount, and place used should be written in on the "Material Used" side. The amount used is subtracted from the previous amount on hand, thus leaving the amount on hand after disbursements. Hence the last amount in the right-hand column represents the amount that should be in the bin of the storeroom.

When the amount on hand, as shown on the inventory card, gets down to the minimum stock, it is time to requisition more material. Fig. 2 shows a requisition form. The requisitions should be made out by the electrical storekeeper and numbered in the order they are issued. In the form shown, the requisition number is placed in the requisition number column of the inventory card, as well as in the upper right hand corner of the requisition form.

On the line above the approval space the use of the materials ordered is given. At the end of this line the account to which this material is to be charged is given. In this case it is to "Stores" as it will be charged out as used. On some construction jobs or special repair jobs the material is charged direct to the job. Therefore, a special account number should be assigned.

In the columns marked "Bin Number," the inventory number of the material is written, so as to provide positive identification of the material when it is received at the plant. In the next column the quantity on hand at the time of requisitioning is given. Next are given the consumptions for 3 months, 6 months, and 12 months. This can readily be found from the "Materials Used" side of card. These consumptions and the quantity on hand are given so as to show to the persons who must approve the requisitions that the materials are really needed. Also, it tends to keep the storekeeper from ordering too much or too little material at a time, for since he actually determines these figures he can see what past requirements were and can accurately judge the future needs.

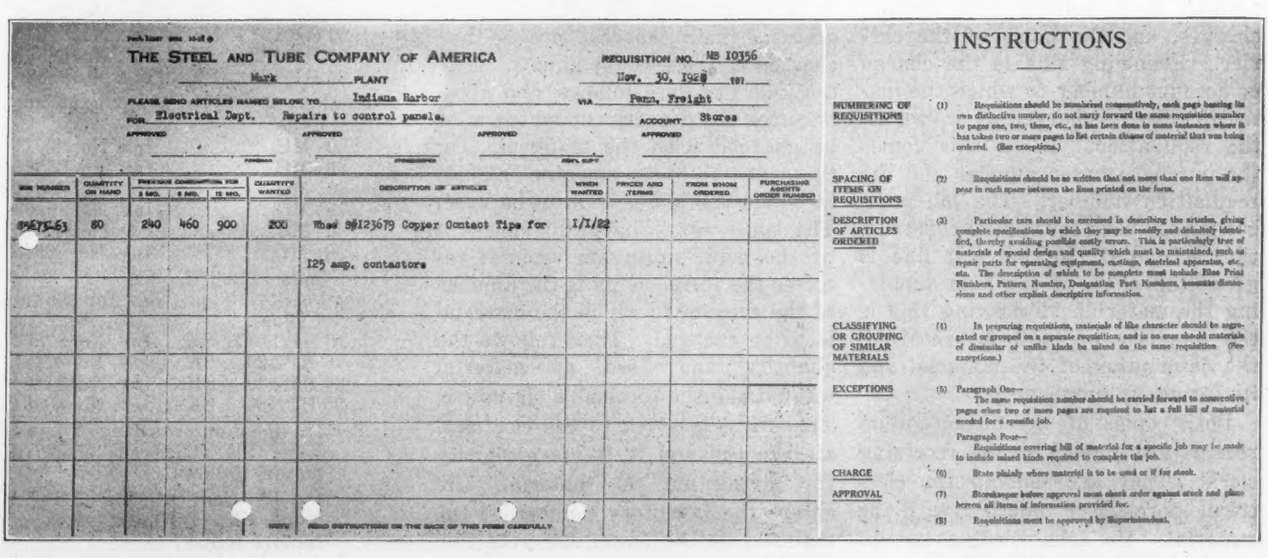
In the column after the consumptions, the quantity wanted is given. Following that is the description of the article wanted. This should be complete as given on the inventory card and should include the manufacturers' style number, drawing number or pattern number, so that the manufacturer can readily determine the material desired.

The next column is for the delivery desired. This column is not intended for the words "At once." Material should be ordered sufficiently in advance to give the purchasing department time to get the best terms consistent with delivery and also to permit the requisition to go through the routine channels instead of being telephoned from one department to another and rushed out by special messenger.

The next three columns are intended for the use of the purchasing department. They may be filled in on the electrical superintendent's copy after the purchase order has been placed and a copy of the order received. In any event the purchasing agent's order number should be filled in, for this permits all the important information about an order for material to be kept on one sheet. The electrical department should always refer to its copy of the requisition when expediting the delivery of the material and in such cases it will be found convenient to have the purchase order number on it.

As mentioned before, the electrical storekeeper should make out the purchase requisition. In the works where the forms shown are used, four copies are usually needed and handled as follows: All four copies are sent to the electrical superintendent who signs his approval in the space marked "foreman." He then returns one copy to the electrical storekeeper for the electrical department records. The remaining three copies are sent to the main

Fig. 2—When the amount of material on hand, as shown on the inventory card gets down to the minimum stock, it is time to requisition more material. This is a convenient form of requisition for this purpose.



THE STEEL AND TUBE COMPANY OF AMERICA

REQUISITION NO. MB 10356

Mark PLANT Nov. 30, 1922

PLEASE SEND ARTICLES NAMED BELOW TO Indiana Harbor VIA Penn. Freight

FOR Electrical Dept. Repairs to control panels. ACCOUNT Stores

APPROVED APPROVED APPROVED APPROVED

BIN NUMBER	QUANTITY ON HAND	PREVIOUS CONSUMPTION FOR 3 MO.	6 MO.	12 MO.	QUANTITY WANTED	DESCRIPTION OF ARTICLES	WHEN WANTED	PRICES AND TERMS	FROM WHOM ORDERED	PURCHASING AGENT'S ORDER NUMBER
35675-63	80	240	460	900	200	Whse #123679 Copper Contact Tips for 125 amp. contactors	1/1/23			

NOTE—READ INSTRUCTIONS ON THE BACK OF THIS FORM CAREFULLY

INSTRUCTIONS

NUMBERING OF REQUISITIONS (1) Requisitions should be numbered consecutively, each page bearing its own distinctive number, do not carry forward the same requisition number to pages one, two, three, etc., as has been done in some instances where it has taken two or more pages to list certain classes of material that was being ordered. (See exceptions.)

SPACING OF ITEMS ON REQUISITIONS (2) Requisitions should be so written that not more than one item will appear in each space between the lines printed on the form.

DESCRIPTION OF ARTICLES ORDERED (3) Particular care should be exercised in describing the articles, giving complete specifications by which they may be readily and definitely identified, thereby avoiding possible costly errors. This is particularly true of materials of special design and quality which must be maintained, such as repair parts for operating equipment, castings, electrical apparatus, etc., etc. The description of which to be complete must include Blue Print Numbers, Pattern Number, Designating Part Numbers, accurate dimensions and other explicit descriptive information.

CLASSIFYING OR GROUPING OF SIMILAR MATERIALS (4) In preparing requisitions, materials of like character should be segregated or grouped on a separate requisition, and in no case should materials of dissimilar or unlike kinds be mixed on the same requisition. (See exceptions.)

EXCEPTIONS (5) Paragraph One—
The same requisition number should be carried forward to consecutive pages when two or more pages are required to list a full bill of material needed for a specific job.

Paragraph Four—
Requisitions covering bill of material for a specific job may be made to include mixed kinds required to complete the job.

CHARGE (6) State plainly where material is to be used or if for stock.

APPROVAL (7) Storekeeper before approval must check order against stock and place hereon all items of information provided for.

(8) Requisitions must be approved by Superintendent.

storeroom where approval is necessary to show that they have no such material in stock. They retain one copy for their records and for use in identifying the material when they receive it. The remaining two copies are sent to the general superintendent for his approval. When he has approved the requisition, one copy is sent to the plant expediter for his information in expediting the delivery of the material. The original is sent to the operating vice-president. After his approval, the requisition goes to the purchasing department.

When the purchasing department has placed the order for the material called for on the requisition, what is called a purchase order is issued. This is sent to the firm receiving the order, to the storekeeper, the accounting department, the expediter and the electrical department. On the purchase order is given all the information that is given on the requisition, together with name of firm with which the order was placed, the order number and the price.

When the material is received at the main storeroom, the receiving clerk identifies it from the order number marked on the package by the manufacturer. The receiving clerk then attaches a tag to the material. On this tag is written the description of the material and its inventory number.

Use of Memorandum of Receipts Form

The receiving clerk makes up the form "Memorandum of Receipts" in duplicate. On this form (Fig. 3) is marked the date of receipt, the freight item number, the freight charges, and the name of the carrier. Following this is the charge or account number to which the material is to be charged as shown on the requisition. Below this comes the purchase order number and the requisition number. The job number is only used for special construction accounts. In the next line is given the name of the firm supplying the material. Following this is the quantity of material received, the description of the material and its inventory number.

Both copies of the memorandum receipt are signed by the receiving clerk. They are sent to the electrical storekeeper together with the material. He acknowledges receipt of the material by signing his name to one copy of the form. This is returned to the main storeroom which in turn passes it to the accounting department as a voucher in passing the invoice for payment.

The electrical storekeeper places the material in the bin of the inventory number shown on the "Memorandum of Receipts." He also marks on the memorandum the amount of material he found in the bin at the time he added the new material. The inventory card is then taken from the file and on the material received side and on the same line as the requisition number on which the material was ordered, is placed the purchase order number, the date of receiving, and the amount received, as shown on the "Memorandum of Receipts." On the material used side of the card, the amount on hand is checked against the amount found in the bin at the time of adding the new material. The amount on hand is increased by the amount received by an entry "Received on Order M98343—200."

How the Storeroom Order Is Used

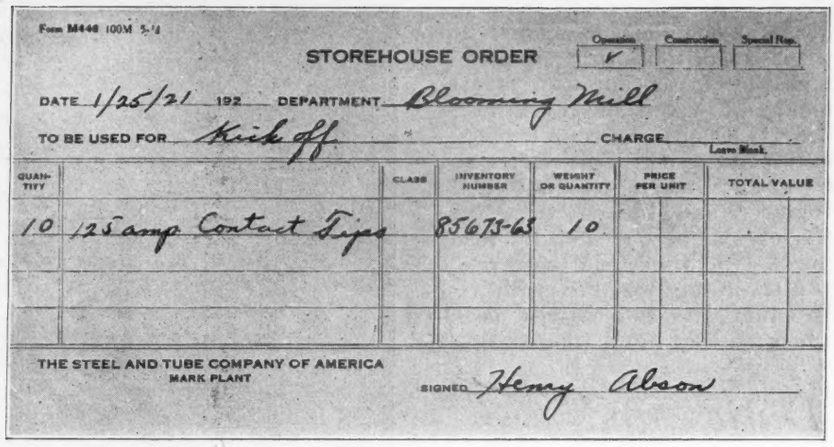
The last form of the series (Fig. 4) is the "Storeroom Order." This is used in charging out material. This form is made out by the foreman on the job that is using the material. He fills out all the spaces except the inventory number, price, total value and "charge." In the upper right hand corner of the form will be found three little spaces marked "Operation," "Construction" and "Special Repair." If the material is to be used for operation, the corresponding space is checked. If it is to be used for either of the others, their spaces are either checked or the account number written in. The date follows, and after it comes the department which is to be charged with the material. On the next line is the machine or place in which the material is to be used. The space for "Charge" is filled in by the main storeroom when it receives the form. This is the number of the account to which the material is to be charged. Then follows the quantity and kind of material wanted and the foreman's signature. This form is given to the electrical storekeeper and it is his authority for giving out the material. He enters the inventory number of the material on the form, and gets this number from the card attached to the bin from which he takes the material. He then finds the inventory card of this number and makes an entry on the material used side, of the date, amount of material used, and the place where used. The amount used is then subtracted from the previous amount on hand so as to give the actual amount now in the bin. When the amount on hand approaches the minimum stock, he issues a new requisition and the cycle of operation is repeated.

The "Storeroom Order" is then sent to the main storeroom where a set of cards is arranged in numerical order for inventory numbers. They find the card of the number called for on the "Storehouse Order," and price the material from their card and make the proper charge of the material. They are able to accurately price the material because when it was received they debited their card with the amount shown on the order for the incoming material. For each "Storeroom Order" received they credit or charge out the amount called for.

The inventory cards at the electrical storeroom are filed according to kind of material. There are several main divisions of the file, such as Armatures, Bearings, Coils, Contactors, etc. Each division is divided into subdivisions and the subdivisions are divided into sections. For instance, under the main division of coils are found the subdivisions of armature, field, stator and rotor coils as follows:

COILS (Division)
- Armature Coils (Subdivision)
  - Section 42—Type SK, Armature Coils
    - 10 HP 110 L SK.....Inv. No. 85675
    - 15 HP 120 SK.....Inv. No. 86546
    - 20 HP 110 L SK.....Inv. No. 86512
    - 20 HP 130 SK.....Inv. No. 86521
    - 35 HP 160 SK.....Inv. No. 86536
  - Section 43—Type MC, Armature Coils
    - 20 MC.....Inv. No. 86521
    - 30 MC.....Inv. No. 86528
    - 40 MC.....Inv. No. 86541
    - 70 MC.....Inv. No. 86565
    - 80 MC.....Inv. No. 86572
    - 90 MC.....Inv. No. 86548
- Field Coils (Subdivision)
  - Section 44—Type SK, for Shunt Fields
    - 10 HP 110 L SK.....Inv. No. 87852
    - 15 HP 120 SK.....Inv. No. 87868
    - 20 HP 130 SK.....Inv. No. 87894
    - 35 HP 160 SK.....Inv. No. 88901
  - Section 45—Compensating Field Type SK (Different sizes of motors follow)
  - Section 46—Commutating Field Type SK (Different sizes of motors follow)

Fig. 4—This is the storeroom order used in charging out material. It is made out by the foreman on the job and given to the storekeeper as his authority for giving out material.



Form M446 100M 5-'4

STOREHOUSE ORDER

Operation ✓ Construction Special Rep.

DATE 1/25/21 192 DEPARTMENT Blooming Mill

TO BE USED FOR Kick off CHARGE Leave Blank

QUANTITY		CLASS	INVENTORY NUMBER	WEIGHT OR QUANTITY	PRICE PER UNIT	TOTAL VALUE
10	125 amp Contact Tips		85673-63	10		

THE STEEL AND TUBE COMPANY OF AMERICA
MARK PLANT

SIGNED Henry Abson

Section 47—Type MC, Shunt Field (Sizes of motors follow)
Section 48—Type MC, Series Field (Sizes of motors follow)
Section 49—Type MC, Series Coils for compound motors (Different sizes of motors follow)
Stator Coils (Subdivision)
Section 50—Type CS (Different sizes follow)
Section 51—Type CW (Different sizes follow)
Rotor Coils (Subdivision)
Section 52—Type CW (Different sizes follow)

It will be noticed that the sections are arranged in the file in numerical order. It is for this reason that the section number is always included as part of the inventory number. It follows the inventory number, separated by a dash, thus, 86573—63.

The most convenient way of filing the inventory cards is a vertical file. The main divisions are separated by red fibre separators with suitable index tabs, and the subdivisions may be separated by green fibre with suitable index tabs. The sections should be in the form of a folder, open at the top, and all of the inventory cards of that section placed therein. On the index tab of the folder should be placed the name of the section as well as the section number. Thus in looking for a certain card in the file, it may be found by looking for the class of material and then finding the right section and then the card in the section. If the section number is known, the proper section may be pulled out at once and the card found immediately.

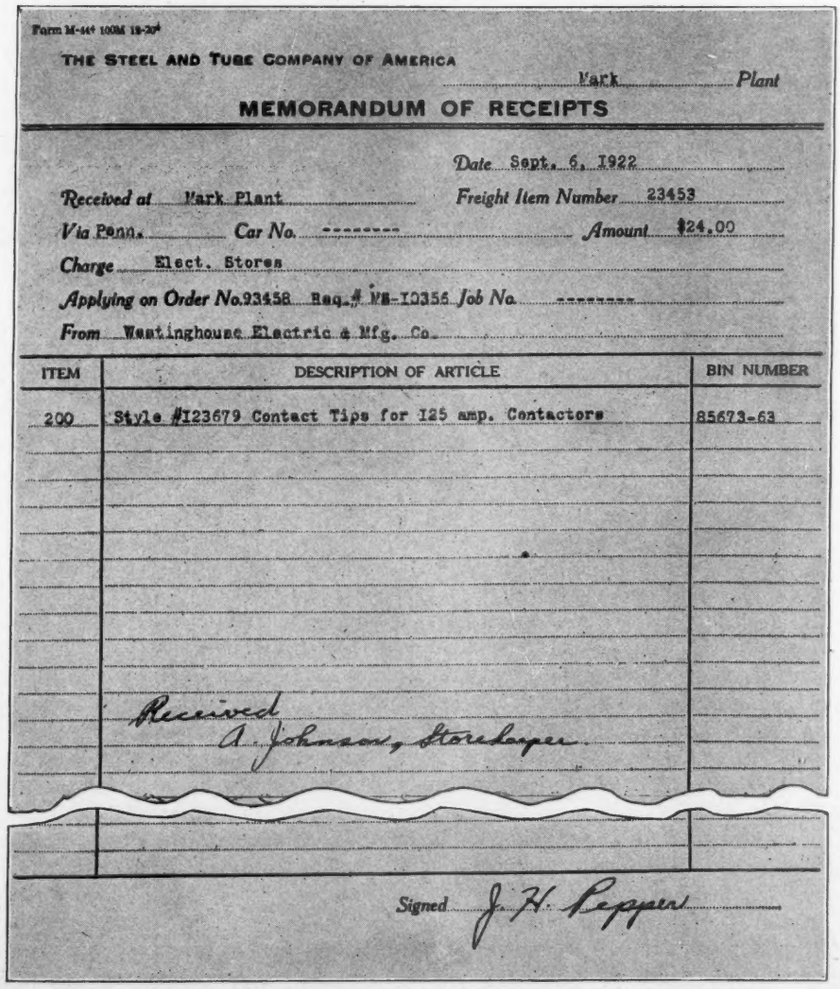
It will be found of value to keep two records of the assignment of inventory numbers to the different kinds of material. One list will be of inventory numbers in numerical order and will give the inventory number, the description of the material and the section to which the material was assigned, as follows:

Inventory Number	Description
85673—Whse. S, No. 123679, Contact Tips	Sec. 63
85674—Bearings Pattern No. 6425	Sec. 21
85675—Arm. Coils for 110 L, SK, 10 HP motor	Sec. 42

This record can be used in assigning new inventory numbers and also to find the section number to which a given inventory number belongs.

The other record is made up in numerical order of sections. Under each section is given all of the inventory numbers of the section and a description of the material for each inventory number. This record is made up as shown in the tabulation giving the arrangement of divisions, subdivisions and sections. This record is convenient in finding the inventory number of a given article, as it is quicker to look through this than through the card file. Both records can be made up in a loose-leaf form of note book.

This method of handling material keeps a strict account of the material and of itself renders an audit of the need, storing and use of material. (*Continued on page* 66)



Form M-446 100M 19-20

THE STEEL AND TUBE COMPANY OF AMERICA
Mark Plant

MEMORANDUM OF RECEIPTS

Date Sept. 6, 1922

Received at Mark Plant Freight Item Number 23453

Via Penn. Car No. -------- Amount $24.00

Charge Elect. Stores

Applying on Order No. 93458 Req. # MS-10356 Job No. --------

From Westinghouse Electric & Mfg. Co.

ITEM	DESCRIPTION OF ARTICLE	BIN NUMBER
200	Style #I23679 Contact Tips for I25 amp. Contactors	85673-63

Received
A. Johnson, Storekeeper.

Signed J. H. Pepper

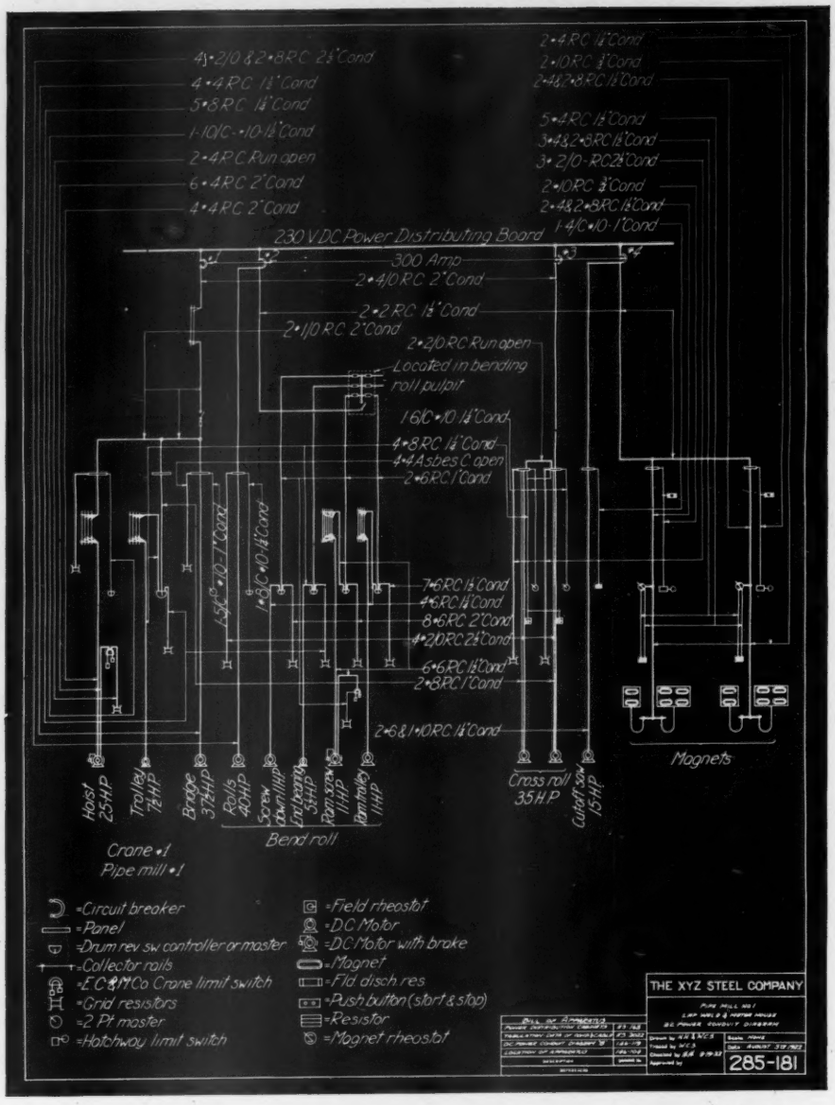
Fig. 3—This form headed "Memorandum of Receipts" is made out by the receiving clerk who sends it in duplicate with the material to the storekeeper. One copy is receipted and sent to the accounting department as a voucher in passing the invoice for payment. The other copy is used in making entries on the inventory card.

IN NEARLY EVERY industrial works at one time or another, the services of a consulting engineer or a mill electrical contractor may be required. When the work to be done is let on a contract basis, the duties and responsibilities of a mill owner or his representative, the engineer and the electrical contractor should be carefully recognized. In this article these points are taken up together with construction data and records needed when figuring installation work.

Duties and Responsibilities of

The Engineer and Electrical Contractor

And Their Relations With the Customer on Contract Jobs in a Factory or Mill



Between this blueprint and the actual installation work which it calls for lie the specialized functions of the consulting engineer and the electrical contractor.

By DANIEL H. BRAYMER
Editorial Director, Industrial Engineer

IN THOSE cases where electric wiring and the installation of equipment in new extensions to industrial plants or changes in existing installations are not executed by the operating organization of the plant, this work is usually handled by contracts made with a consulting mill engineer and industrial or mill electrical contractors. Where this work is extensive it has been found advisable and most economical to retain an engineer charged with the responsibility to draw up specifications, make layouts, plans and cost analyses and sublet the installation work to an industrial electrical contractor who will execute it under the inspection and general supervision of the engineer.

With the growth in extent and character of electric service in mills and factories, two phases of mill engineering have grown in direct proportion. One involves the analysis of service conditions and the planning, specifying and laying out of the equipment required. This work falls to the engineer, working in close co-operation with the mill owner and his operating organization. The other involves the translation of these plans and specifications into details of construction and standards of workmanship. This work falls to the industrial electrical contractor, working in close co-operation with the engineer. The execution of the second phase of the work in connection with new mills and factories and the rehabilitation of old ones has opened a wide field of opportunity for the electrical contractor to establish standards of practice in keeping with engineering ideals of service that will bring to him a recognition for engineering and business ability in the field of electrical engineering of the same order that has been earned by the building contractor in other divisions of construction in the field of civil engineering. In electrical construction work there is a demand for not only good workmanship, but a knowledge on the part of the electrical contractor of electrical and mechanical operations in plant production and those changes and maintenance problems that come with plant expansion and natural wear and tear of the equipment involved. Moreover, there is also a demand for evidences of business judgment and integrity that will merit confidence in the handling of work that calls for the expenditure of thousands of dollars in materials and labor.

In the execution of industrial electrical construction work under the conditions that have been named, three parties are involved. First,

the mill owner or customer; second, his engineer or his engineering representative, and, third, the electrical contractor. On every job each has distinct and separate duties and obligations, and since in this article we are dealing with the problems of electrical construction on conditions that might be considered ideal or those worth while to aspire to, it will be in order to list the range of duties and responsibilities of these three parties to a job.

In the case of the mill owner and customer they are:

1—The detailing of responsibility for important engineering work to an engineer of recognized standing. This is not only a matter of good judgment on the part of the mill owner or customer, that he may obtain the most efficient return on the investment of his capital, but it is a vitally necessary condition to obtaining fair competition on the actual work of construction when the contract for installation work is being let. For without the detailing of such responsibility to a qualified engineer the mill owner cannot always intelligently compare bids which may be submitted, nor can he be assured of receiving the full value for the money he is investing.

2—The appointment of one or more members of the plant operating organization to work with the engineer in the analysis and layout of the work to best meet production procedure, general maintenance and upkeep as carried out in the works.

3—The financing of the work.

In the case of the engineer they are:

1—To prepare definite and detailed plans and specifications, which may be the basis of bids by contractors and cover the work to be done as completely as possible, minimizing the amount to be performed as an extra to the contract.

2—To set standards of quality and kind of equipment to be used.

3—To set standards of quality and kind of workmanship to be required of the contractor.

4—To compare bids for work and judge responsibility and integrity of contractors submitting these bids. This includes advice to the customer on the details of the bids and his knowledge of and experience with contractors bidding as regards their technical and financial qualifications for handling the work.

5—To inspect installation work and require its strict conformity to specifications.

6—To adjust conflicts or interferences between the work of different contractors on the job, involving such items as location of apparatus, piping, wiring, etc., and fairly to place the responsibility for any additional expense that may be involved.

7—To authorize items of work extra to the contract not included in the original specifications when such work originates after drawing up specifications and securing bids, and to adjust changes in contract price resulting from changes in original specifications.

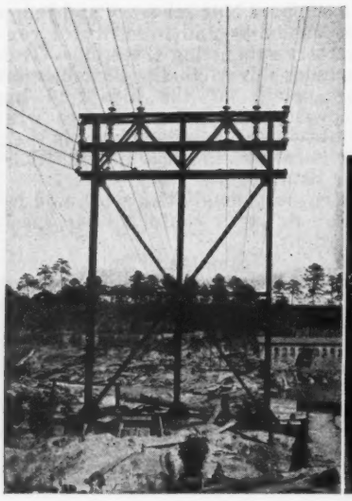
In the case of the electrical contractor they are:

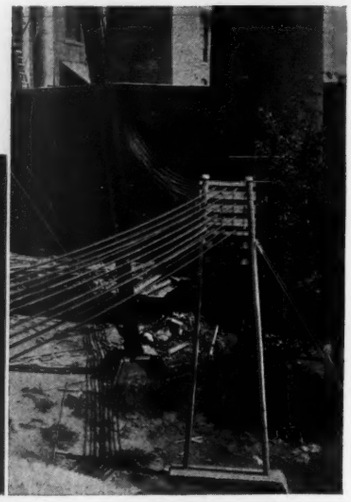
1—To execute all work in accordance

Table I.—Types and Sizes of Materials Required for Emergency Stock When Handling Electrical Construction in Mills and Factories

Angles—flat galvanized and black channel.
Boxes—galvanized and cast iron.
Boxes—outlet and switch.
Box Connectors.
Bolts—all sizes and lengths, galvanized.
Blocks, Test.
Bus Copper and miscellaneous switchboard fittings.
Bushings—Federal type.
Bushings—galvanized conduit.
Condulets and Covers—all popular types and sizes ½ to 4 in.
Conduit—ells and couplings.
Conduit—flexible metallic.
Clamps—Mathews 4-bolt cable.
Compound—cable bell.
Cleats—All sizes and voltages 1,000,000 c.m. and smaller.
Cross Arms—galvanized.
Cross Arms—braces galvanized.
Cutouts—complete line 600, 250, 125 volts.
Dosserts—all sizes type A and S for 750,000 c.m. to 0000 B. & S.
Fixture Studs.
Floor Rings—split, nickel plated.
Fixture Loops—Besco 16801.
Fuses—all sizes and voltages.
Fire Extinguishers—one qt. Pyrene.
Flexduct—all sizes ⅛ to 2 in.
Forks—561 Pierce galvanized.
Ground Clamps—⅜ to 4 in.
Guy Material—anchors, turnbuckles, insulators, thimbles and clamps.
Insulators—2200 volt pin type and wood strain.
Knobs—5½ Nailet.
Lugs—all sizes up to 1,000,000 c.m.
Lighting Brackets—street series.
Lightning Arresters—compression chamber 220, 550, 2200 volt.
Lag Screws, Galvanized—from ⅜ by 2 to ⅝ by 6 in.
Lead—sheet and ¼ in. pipe.
Lamp Cord—G and Y and reinforced 18 B. & S. and 14 B. & S.
Lock Nuts—conduit.
Moulding, Wood and Fittings.
Motors and Bases—as required.
Nuts—galvanized machine bolt.
Poles—30 and 35 ft.
Pipe Railings and Fittings.
Pole Steps—galvanized.
Pipe Straps—6 in. and smaller, galvanized.
Racks, Pierce—secondary 5, 3 and 2 spool.
Receptacles—all popular types.
Rosettes—all popular types.
Bases—all popular types.
Wood Screws—round head, blued 3½ No. 16 and smaller.
Screw Hooks—No. 1 and 1818 G, galvanized.
Switches—knife, 200-amp., 250-volt and smaller; 100-amp., 600-volt and smaller.
Switches—entrance.
Switches—safety miscellaneous.
Switches—push, snap, tumbler and door.
Switches—miscellaneous.
Switch Plates and Receptacle Plates—solid and stamped, BB and nickel.
Solder and Paste.
Sockets—P. B. key, keyless and pull chain.
Tools—for sale at cost to workmen.
Tape—rubber, friction, varnished cambric and weather proof.
Tubes—porcelain 2-in. by 30-in. and smaller.
Wire and Cable—Underwriter's white, 750,000 c.m. to 12 B. & S.
Wire and Cable—RC 0000 to No. 14.
Wire and Cable—VC 0000 to No. 12.
Wire and Cable—WP 750,000 c.m. to No. 10.
Wire and Cable—Miscellaneous—portable cord; flame proof; switchboard cable; colored braid, switchboard cable; 2200 volt triple conductor leaded cable; galvanized telephone wire.
Washers—galvanized ⅝ and smaller.
Transil Oil and P. B. Paint.
Reflectors—R. L. M. standard.
Pins and Oak Brackets and miscellaneous telephone line material.

Note: On January 1, 1923, the value of these materials on hand in the stockroom was about $25,000. Stocks about $1,000 in value included: Condulets, $2,461; Conduit, $1,456; Fuses, $924; Bolts, $911; Flexduct, $894; Sockets, $1,311; Tubes, porcelain, $1,317; Wire and Cable, $1,326.





Some mill installations call for heavy and permanent construction for service connections to buildings. Here it was necessary to cross a river. The illustrations show the supports which were used for carrying twelve 750,000 c.m. cables from the substation to the mill.

with the spirit as well as the letter of the specifications.

2—To establish and maintain high standards of workmanship.

3—To plan the execution of work in such stages as will conform as fully as possible to the convenience and requirements of the customer and the schedules of other contractors executing other and associated parts of the installation work.

4—To provide such emergency stock as will prevent interruptions in the work under his contract through delays in shipments by manufacturers.

5—To make sure that the work is complete and conforms with specifications before calling upon engineers for final inspection.

6—To keep the clearest possible records of all extra work performed and to perform no extra work without the authorization of engineer or customer.

7—To establish such credit standing and standards of integrity as will guarantee the performance of a contract in all its engineering and legal details.

8—A responsibility of the good contractor, sometimes overlooked, is to place upon the work a foreman and a crew of men whose standards of integrity and conduct will at least conform to those of the community in which they are placed and in no way be an offense to the customer.

A contract form is an essential part of specifications for installation work which should be carefully prepared from the standpoint of completeness and clearness of installation requirements that will be considered by the engineer in his inspections and approvals of work done by the electrical contractor. Such a contract form as prepared by the engineer should cover the following points:

1—Duties and responsibilities of the electrical contractor.

2—Work covered by the specifications and quality of the materials that shall be used together with references to official rules and standards of insurance companies, state or municipal ordinances that must be met.

3—Separate outlines of the different parts of the work contemplated and schedules giving the order of handling it when the operation of existing machinery is to be considered.

4—Detailed drawings interpreting specifications and plans showing locations of apparatus, buildings and main circuits.

5—Inspection procedure and fees when municipal and state inspections are required.

6—Conditions under which work will be handled that represents additions, omissions or defects.

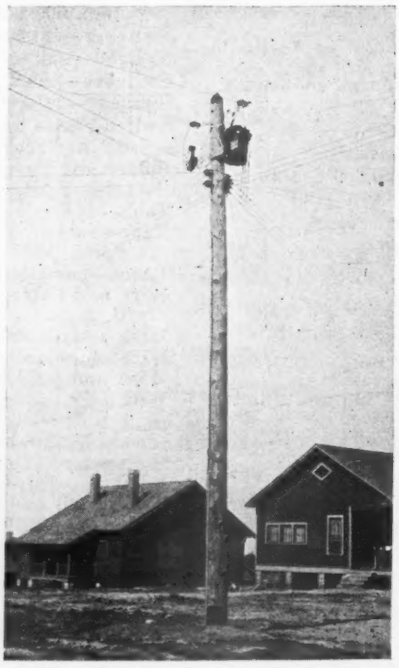
7—Conditions surrounding progress and completion of work.

8—Terms of payment for work done.

9—Requirements for final acceptance of work done.

10—Procedure covering conflicts in the work handled by different contractors.

11—Schedules of equipment to be purchased by the mill owner and the electrical contractor.



This is a typical construction for lighting of cotton mill villages surrounding the mill.

12—Explanations under separate headings in the specifications covering the general procedure to be followed in installing each element of the job and the character of workmanship expected. Such explanations should usually cover: Supports, joints and conductors for general wiring; provisions for and kind of exposed and inclosed wiring; requirements as to wiring devices and their locations, etc.; special clearances and special equipment that shall be used. These and like details are essential in addition to the usual detailed specifications covering layout and character of each specific installation or system shown in the layout drawings and detailed plans.

In most cases where a qualified engineer is retained by a mill owner the duties and responsibilities of each are simple and are well recognized. In other cases the duties and responsibilities of the electrical contractor are not so well recognized as they are inferred and legally made binding through the details of the contract as already outlined. In some cases the engineer undertakes a responsibility, often unfairly to himself, of compelling performance of work in accordance with the contract and frequently assumes that he can secure a kind of service in workmanship and ability gained only through experience that the electrical contractor does not possess and does not in any way reveal except through a low estimate in competitive bids. No criticism is intended for the engineer in this statement further than to say that he is in such instances assuming a responsibility in the execution of work on the sole basis of the lowest bid that is not fair to himself and his client and not conducive to the establishing of electrical construction work on such a business basis as will enable the electrical con-

tractor to build a capable and experienced personnel; to assure the performance of the details of specifications in contract form; or the building of a reserve in business capital that will enable him to establish and maintain the emergency stock that is so essential to the completion of work without interruptions or delays.

A worse but less frequent modification of this practice is the submitting of the amounts of the total bids to the client for decision after selecting two or three of the bidders who are close together. The fallacy of this practice can be best illustrated by an example. Suppose a doctor is called for a patient who has measles. He shows the patient three medicines, all of which will be in varying degree effective but differ in cost by small amounts and then asks the patient to select one from which the dose will be prescribed. If a physician should follow such a practice his sanity would promptly be questioned by the medical profession.

In the case of electrical contractors, there is often found a deficiency in business methods and good judgment evidenced by a wildness of desire to secure a job without a definite and accurate knowledge of all its costs and the probable contingencies that are involved. On the other hand, some electrical contractors handling mill installations have spent much time in analyzing their work and devising detailed methods which show the necessary assurances and checks to be made in order that not only one but every job undertaken can be executed according to standards that will be easily recognized as complying with the most rigid of specifications, if they do not provide examples of improved practice gained through the experience of the capable men that they are thus enabled to employ.

Table II.—Main Items of Materials Needed on Three Different Kinds of Jobs

Materials Used	Job No. 1 Motor Installation only—91 Motors, 1408 hp.	Job No, 2 Lighting and motor installation—490 lights, 200 watts each and 431 motors, 1057 hp.	Job No .3 Lighting Installation only—716 lights, 150 watts each.
Wire	22,000 ft.	92,000 ft.	64,500 ft.
Conduit	6,000 ft.	26,100 ft.	18,300 ft.
Ells	350	400	95
Couplings	350	400	95
Flexible Metal Conduit	270 ft.	880 ft.	.....
Lock Nuts	1,700	2,360	2,950
Bushings	850	2,360	2,950
Flexible Box Connectors	180	600	.....
Split N. P. Floor Rings	30	204	120
Pipe Straps	1,200	4,550	3,700
Condulets	375	1,730	170
Fibre Conduit	.....	860	.....
Test Blocks	.....	117	.....
Cutouts	185	327	200
Fuses	185	1,010	850
Cutout and Junction Boxes	102	595	255
Asbestos Board	.....	265	.....
Gal .229 G. E. Compound for Potheads	15	32	.....
Pierce Racks	10	4	24
Gross of R. H. Wood Screws	16	32	70
Machine Bolts	85	85	80
Stove Bolts	600	630	700
Channel Iron	50 ft.	35 ft.	.....
Angle Iron (Galvanized)	24 ft.	.....	144 ft.
Ground Clamps	500	600	.....
Lugs for Cutout Boxes and Grounding	200	200	.....
Solder	100 lbs.	200 lbs.	125 lbs.
Paste	5 lbs.	20 lbs.	13 lbs.
Tape, Friction and Varnished Cambric	50 lbs. each	400	160
Total	$5,212	$15,100	$7,630
Miscellaneous	3,600	700	150

Job No. 1.—Miscellaneous items include: Motor supports, switch supports, gasoline, paint, hardware, bus bars and insulators, grounding material, iron for substation and transformer foundations—$3,600.

Job No. 2.—Additional items included: Outlet boxes, distribution panels (6); magnetic switches (4); reflectors RLM (490); and safety switches (51); circuit breakers (2). [Miscellaneous: Gasoline, paint, hardware, cutout supports, concrete and brick manholes; 1,000 ft. lead pipe for anchoring boxes and straps, bushed elbows, special castings, and junction boxes—$700.]

Job No. 3.—Additional items included: Outlet boxes (1,050); reflectors RLM (715); swivel RLM hangers (716); safety switches (175). [Miscellaneous: Gasoline, paint, hardware and supports for safety switches—$150.]

Character of Work That Is Covered by Table II

Job No. 1.—A straight motor installation of 91 motors, 1408 hp. The motors were operated on a 3-phase, 550-volt distribution system. The wiring was an all conduit job, overhead attached to wood beams.

Oil circuit breakers and compensators were used with motors and a few magnetic switches with push buttons.

The customer furnished the motors and switches and transformers.

The contractor furnished the substation structure and a long underground cut-in (100 ft.), using parkway cable installed in the ground without conduit. The work was done in a textile mill of slow burning mill construction.

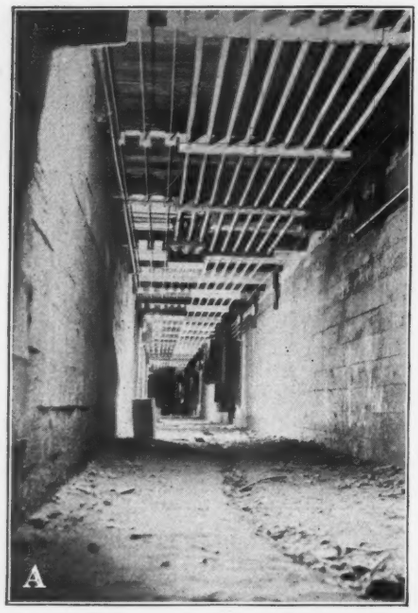
The total cost was as follows:

Material (substation equipment of $1,146 but no transformers or electrolytic arresters. Labor of $310)	$ 8,812
Labor	2,426
20% Commission	2,538
	$13,776
Substation	1,456
	$15,232

Job No. 2.—A mixed lighting and motor installation of 490 lamps, 220 watts each, and 431 motors totaling 1,057 hp. The work was done in scattered concrete buildings with all wiring exposed in conduit. The main switchboard was about 150 ft. from the service substation and it was practically 400 ft. from stepdown transformers to center of distribution. Between transformers and switchboard lead-covered cable was used in fiber conduit. The feeders from switchboard to center of distribution and to load were installed in conduit.

The motor job included 336 ½-hp. individual loom motors at 220-volt, 3-phase, with snap switch control; 47, 7½-hp. spinning frame individual motors with oil circuit breaker control but no compensators. There were 50 group motor drives and 5, 30-hp. motors using compensators or oil circuit breaker control. The motors other than those on looms were 550-volt, 3-phase and the lighting service was at 220-110 volts, single-phase, 3-wire from a 550-volt, 3-phase supply.

The lighting installation was in conduit and included 200-watt RLM units with small group control.



Examples of Good
Electrical Installations
In a Cotton Mill

A—Construction in a feeder tunnel showing 500,000 c.m. feeders attached to the concrete ceiling.

B—Motor mounting on concrete ceiling without motor supports for 4-frame spinning drives. Fuse box and switch are also shown attached to ceiling with short conduit runs.

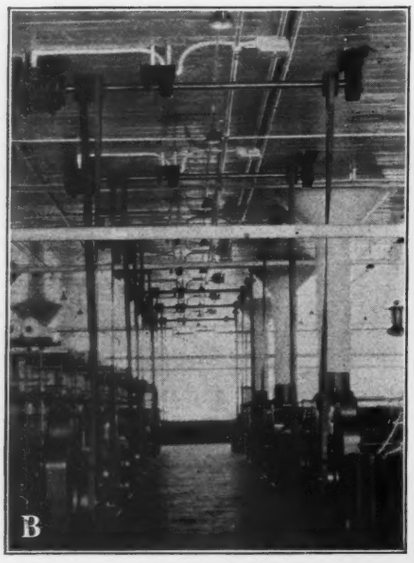
C—Insulated turnbuckles with 3-in. fibre conduit sleeves instead of tape protecting live parts. The cleats below permit lowering of sleeves for adjusting turnbuckles.

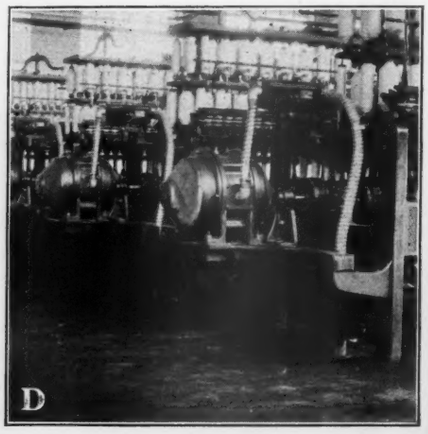
D—Individual motor and switch mountings on spinning frames.

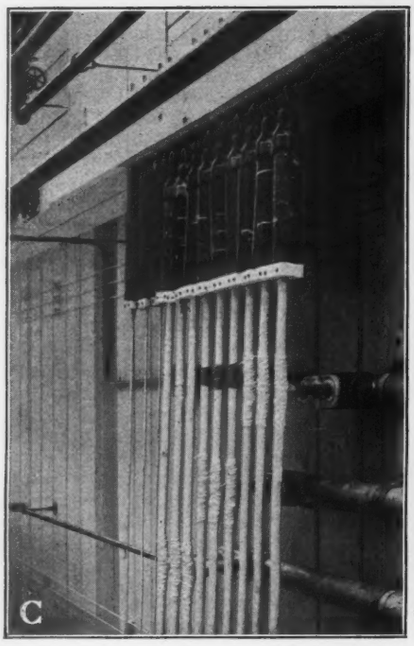
E—Messenger wire supports for mounting feeders to Cooper-Hewitt lights.

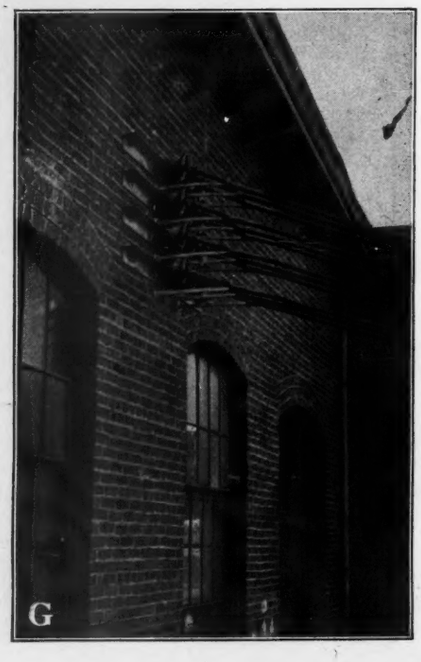
F—Another type of motor and switch mounting for looms.

G—Strain supports for heavy feeders where they enter the building.









The customer furnished the motors, control devices, switchboard and transformers. The contractor furnished all of the motor supports, distribution panels and wiring materials.

The total cost was as follows:

Material	$15,800
Labor	5,510
15% Commission	3,196
	$24,506

Job No. 3.—An all lighting job of 716 lights, 150 watts each. This was a change-over job in an old mill of slow burning mill construction in very scattered buildings. The entire distribution was at 220-110 volts, 3-wire from a 220-volt source of supply. RLM 150-watt units were used.

All wiring was in conduit on wood beams. The beams were bored for ½ and ¾ in. tubes and spanned for larger sizes. The feeders tapered as the load reduced. All feeders and switches were installed for the ultimate job but only one-half the total number of lights was installed. On remaining sections temporary connections were made to existing feeders.

The total cost was as follows:

Material	$ 7,780
Labor	3,068
15% Commission	2,077
	$12,925

Table III.—Convenient Form for Summary Sheet Used in Making Up Estimates on Installation Work

ESTIMATE NO. 1 DATE January 1, 1923

CUSTOMER John Jones ADDRESS Jonesville, N. C.

WORK Cotton mill electrical installation

ENGINEER John Doe SPECIFICATIONS NO. 100 DATE Dec. 20, 1922.

I - MATERIAL:

1 - Underwriter's Wire	$ 11.90		
2 - ___Percent on same	$ ------		
3 - Weatherproof Wire	$ 9.95		
4 - ___Per cent on same	$ ------		
5 - Varnish Cambric Wire	$ 5394.25		
6 - Rubber Covered Wire	$ 460.31		
7 - Wiring Devices and Supplies	$ 9858.72		
8 - Extra Freight & Express	$ 100.00		
9 - Truck	$ ------		
		TOTAL	$15,835.13

II - LABOR AND LABOR EXPENSES:

1 - Labor	$ 4350.00		
2 - Foremanship & Expenses	$ 600.00	- 20 weeks at $30	
3 - Expenses of ( ) Men	$ ------		
4 - Time and Exp. of Men in Travel.	$ 150.00		
5 - Build Stock Room	$ 50.00		
6 - Handle Stock	$ 50.00		
7 - Miscellaneous Errands	$ 25.00		
8 - Scaffolding	$ 50.00		
9 - Liability Insurance	$ 100.00	TOTAL	$ 5,375.00

III - MISCELLANEOUS EXPENSES:

1 - Office Expenses	$ -----		
2 - Travel. Exp. of Inspection	$ 75.00		
3 - License	$ 50.00		
4 - Tools	$ 50.00		
5 - Bond			
6 - Inspection Fee		TOTAL	$ 175.00

Total of all above	$21,385.13
IV - COMMISSION ON MATERIAL, LABOR & LABOR EXPENSES, AND MISCELLANEOUS AT 10% OVERHEAD	2,138.51
V - ITEMS WITH SPECIAL COMMISSION: $ TOTAL	$
VI - ITEMS WITHOUT COMMISSION: $ TOTAL	$
VII - CONTINGENCIES TOTAL	$ 1,000.00
GRAND TOTAL	$24,523.64
PRICE OFFERED	$24,525.00

Job was let for less than $21,000 to another electrical contractor.

I—Material:
Item
1—All conduit job—wire used for grounding.
2—Used when item is large because manufacturers will not guarantee weights within 3 per cent. This 3 per cent is added.
4—Same.
5—Used on power wiring throughout and large lighting feeders.
6—Small lighting feeders and mains and branches.
7—All wiring material and miscellaneous material.
8—Buying done on quotations f.o.b. job. Jobbers and manufacturers usually ship collect. This item also covers shipping tools and tool boxes to the job.
9—For job within radius of company truck from headquarters. Ordinarily customer trucks materials.

II—Labor:
Item
2—Pay foreman's living expenses up to $10 per week in addition to wages. He is expected to use about one-half his time in productive labor. On small job 100 per cent time in productive labor is expected.
3—Bonus to cover high living expenses during war. No living expenses allowed at present.
5—Men must have working space; space is sometimes furnished by mill.
6—Unpacking and sorting on shelves made from boxes used in shipping.
8—Building solid bucks and special heavy scaffolding with lumber furnished by mill. Normal breakage in step-ladders and straight ladders.
9—Liability to men and public based on pay roll. Runs up to 10½ per cent on some classes of work.

III—Miscellaneous Expenses:
Item
3—When out of state to cover state license.
4—Concrete mill construction wears out drills. No charge made for wear and tear but only drills actually consumed.
5—Municipal job only.
6—In cities only and covers city inspection.

V—Items With Special Commission: May be called upon to furnish motors and large transformers purchased by contractor.

VI—Items Without Commission: When agreement is made to draw plans and do layout, no commission is charged but billed as special work.

VII—Contingencies: Unusual work or conditions with undue hazards. In this case it was state contract with unusual conditions.

Table IV.—An Analysis of Seven Motor Installation Jobs Showing Cost Per Horsepower. No Commission Is Included.

Job No.	RATING AND NUMBER OF MOTORS					TYPE OF JOB	INSTALLATION COSTS				
	Volts	Hp.	50 Hp. and over	10 Hp. to 50 Hp.	0 to 10 Hp.	Open or Conduit	Total	Material	Labor	Cost per Hp.	Types of Motor Drives
1	550	900	0	5	128	Mixed	$3925.00	$1981.00	$1596.00	$ 4.35	Individual
2	550	583	0	12	56	Conduit	3575.00	2329.00	886.00	6.15	½ Ind. and ½ group.
3	550	155	0	3	17	Conduit	1993.00	1163.00	560.00	12.80	½ Ind. and ½ group.
4	550	730	1	9	75	Conduit	3219.00	1902.00	887.00	4.40	½ Ind. and ½ group.
5	550	147	0	7	3	Conduit	1442.00	914.00	330.00	9.80	All group.
6	550	2765	24	68	3	Cleat	11700.00	7459.00	2976.00	4.20	All group.
7	550	550	0	7	70	Mixed	5400.00	3734.00	1122.00	9.85	⅗ Ind. and ⅕ group.

REMARKS:

Job No. 1—Unusually good feeder condition in that motors were closely grouped around center of distribution which was about the same as the switchboard location.

Job No. 2—A representative installation.

Job No. 3—Very exceptional feeder condition with long loops of 300,000 c. m. cable for connecting two generating stations.

Job No. 6—All group drive consisting of 75 and 50 hp. motors, except spinning frames which were all 4-frame drives.

Job No. 7—Included receptacle circuit throughout mill for portable extension lights and electric drills.—Unusually costly design of motor support was used and long underground cut-in.

The variation in cost per hp. is nearly in inverse proportion to size of job in hp. On certain jobs the contractor furnished motor supports for ceiling mounting and the customer furnished brackets on machines.

In the accompanying tables are set forth some of these methods and the data and information that is essential to an installation cost analysis of mill construction work in the installing of electric service. Table I shows the items that are considered essential by one large contracting company in their reserve or emergency stock to insure against delays in shipments or incomplete shipments of materials by manufacturers. Such a reserve stock cannot be built from the odds and ends left over from various jobs but must be an orderly stock complete in essential sizes and types. However, to such a stock certain quantities of leftover materials such as wire and cable can be added. But in a carefully made up bill of material for every job, such odds and ends should be negligible in quantity. Table II is made up from estimating sheets on three different types of jobs indicating the main items of materials required that are listed more briefly in a schedule form shown in Table III. Under the head of materials, this estimating schedule serves as a final check on the work to be done and presents the requirements of the job in such form that it is complete and easy for filing and for reference when estimates on other jobs are being prepared.

Table IV represents an analysis of motor installation costs that is useful in the same connection. It shows the trend of costs during the period the work is being done by the type and extent of the installation, the kinds of materials required and the amount of labor involved. Table V shows a similar analysis for lighting installations. These data do not lend themselves to definite conclusions or comparisons of costs and should not be so used, for the particular (*Continued on page* 66)

Table V—An Analysis of Nine Lighting Installations Showing Cost Per Square Ft. Lighted and Per Unit Used. No Commission Is Included.

No. of Job	Floor Area Lighted	No. of Lamps	Watts	No. Lamps	Watts	Total No. Lamps	Total Watts	Watts per Sq.Ft.	WIRING		INSTALLATION COSTS				
									3-Wire or 2-Wire	Open, Moulding, or Conduit	Total Cost	Cost per Sq. Ft.	Cost per Light Unit	Total Cost Material	Total Cost Labor
1	78,500	286	200	....	....	286	57,200	0.73	2	Conduit	$4253	$0.054	$14.90	$2718	$ 862
2	109,500	408	200	17	75	425	82,875	0.755	3	Conduit Cleat Mains and Cond. Brchs.	3865	0.0352	9.10	2394	955
3	62,000	245	200	9	75	254	49,675	0.800	3	Conduit	2458	0.0396	9.70	1478	659
4	33,250	185	150	....	....	185	27,800	0.84	3	Cleat	1825	0.055	9.90	1087	467
5	126,800	359	200	37	75	396	74,575	0.6	3	Cleat feeders Cond. M. & B.	5832	0.046	14.75	2950	2080
6	18,600	114	200	....	....	114	22,800	1.23	3	Conduit	1350	0.069	11.80	899	278
7	23,100	84	200	....	....	84	16,800	0.72	3	Cleat	770	0.033	9.10	399	265
8	110,000	381	200	36	75	417	78,900	0.71	3	Conduit	5280	0.048	12.60	2741	1375
9	34,400	122	200	2	75	124	24,550	0.72	3	Conduit	1296	0.038	10.45	674	453
Average	66,239					254	48,352				$2992	0.0348	11.37	1704.44	821.55

REMARKS: The factors entering into the "Cost Per Light Unit" are: (1) Quality and color of goods made. (2) Ceiling height and size of reflector required. (3) Conduit or cleat wiring. (4) Number of floors in building—risers and distribution therefrom. (5) Voltage of supply circuit—and consequent size of feeder to distribution transformers from source of supply.

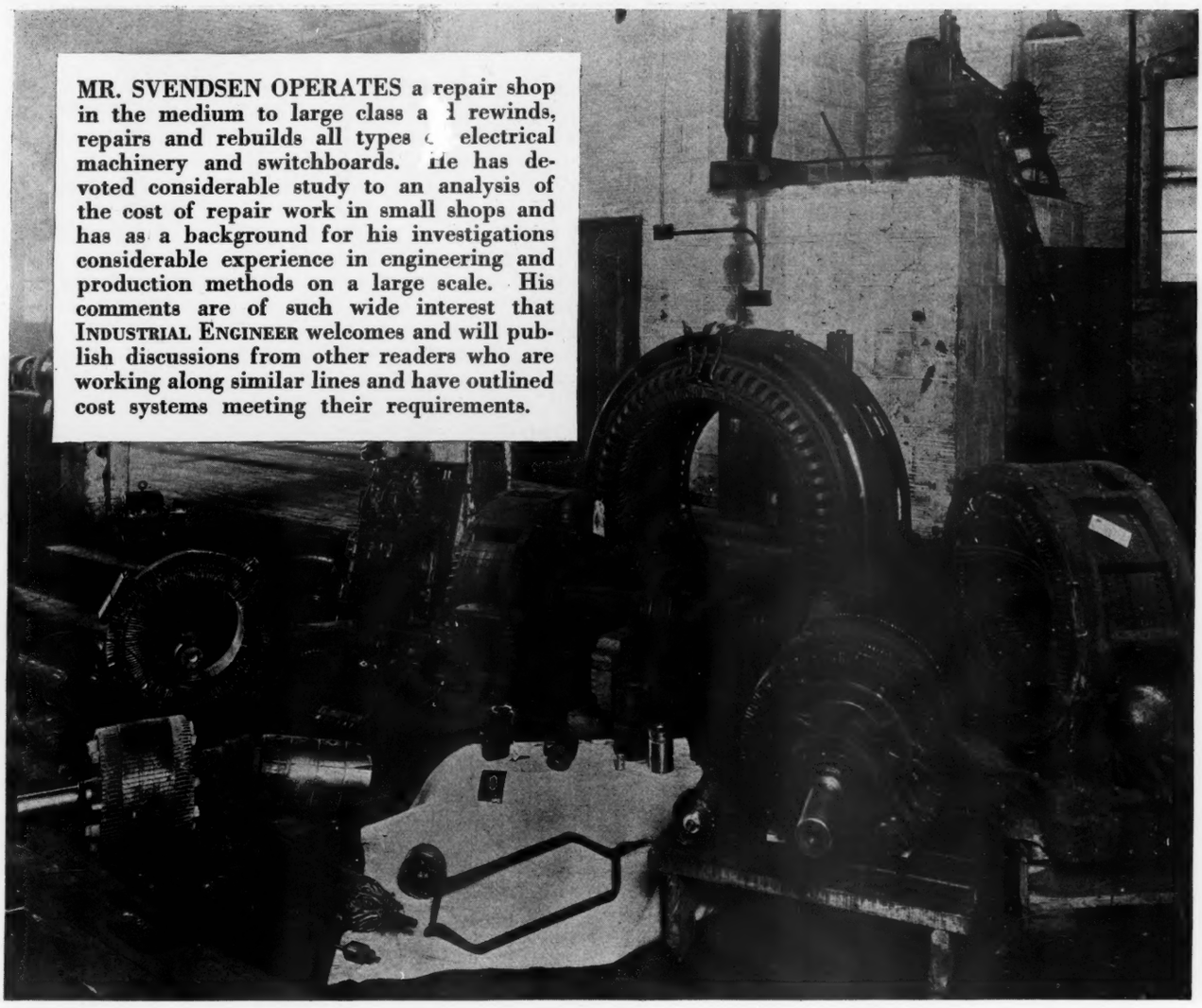
Job No. 1—A 2-wire distribution system with source of supply 400 feet from center of distribution. Double throw switching was required.

Job No. 2—Reflectors were furnished by the customer.

Job No. 3—Source of supply was center of distribution.

Job No. 5—Only part of transformers furnished but switches and risers for double the lighting installed.

Job No 8—Provided feeders for double the lighting service installed.



MR. SVENDSEN OPERATES a repair shop in the medium to large class a l rewinds, repairs and rebuilds all types c electrical machinery and switchboards. He has devoted considerable study to an analysis of the cost of repair work in small shops and has as a background for his investigations considerable experience in engineering and production methods on a large scale. His comments are of such wide interest that INDUSTRIAL ENGINEER welcomes and will publish discussions from other readers who are working along similar lines and have outlined cost systems meeting their requirements.

This photograph shows the wide range of jobs that come to a repair shop. Between the tiny armature in the foreground and the large stator in the background lie the elements that call for time, materials and experience and obey no set rules.

Some Problems Faced When

Analyzing Electrical Repair Shop Costs

That Make a Schedule of Prices Little More Than a Rule of Thumb Guide

By GEORGE P. SVENDSEN,
President, Boustead Electric & Mfg. Co., Minneapolis, Minn.

THE average commercial repair shop that is doing a wide variety of work at a fair profit has reached that point largely through main strength, awkwardness and considerable experience. When the labor and material costs for one particular class of work have been fairly well analyzed along comes the special job, that takes more time and special treatment and the refinement of a former analysis of costs again must be modified by good judgment and some luck in having available a coil winder who possesses a little initiative along with considerable skill.

Every man who is operating a repair shop has his own methods of getting at the proper billing price for a job, which is built up on a time and material basis with additions for the elusive term "overhead" that are good, bad and indifferent. There are several schemes for distributing overhead expense on different jobs that represent modifications between a flat percentage on the cost of labor and material to the complicated machine-rate and man-rate method. Most shops simply set a flat rate varying from 40 to 60 per cent of the cost of labor and material or they use a flat rate for covering the labor of all kinds that is required.

On the face of it, it hardly seems logical to charge the same rate for a man working outside the shop with a few hand tools as for the man using a high-priced machine requiring floor space, power, light, etc. Then to complicate matters, there is the problem of high-priced experts

Here again is an illustration of how a profit is made or absorbed on a job in direct proportion to the number of benches and the presence or lack of nimble hands and wide experience.

who are put to work on jobs that a cheaper man could do, simply because they must be regularly on the pay roll to be available at all times for the particular kind of work at which they are skilled.

Here is another of our repair shop problems that the ordinary cost man doesn't get, and that is the great variety of our jobs. For example, our system of cost records must be able to take care of a big machine requiring all classes of labor and material, including engineering service, and still not be too cumbersome to take care of a little half-hour fan repair job requiring practically no material.

I am now working on a plan of classifying labor according to equipment and type of man normally required and making up a schedule of hourly rates accordingly. This will involve a new time card arranged for machine record, and is quite a problem to work out and still keep the bookkeeping within reasonable limits.

When this matter of analyzing costs is taken up in a detailed fashion, it is usually found that the subject is taken up from an accountant's viewpoint and the conditions found in a large factory geared up for quantity production, with little consideration given to the problems and operating conditions found in the small jobbing or repair shop.

About the first thing any cost expert recommends is a locked stock room with material issued on requisition only. This is fine for the ordinary factory but hits a snag in our work because so many jobs require only minute quantities of material whose individual cost is less than the cost to handle the requisitions. This almost broke up our stock room proposition until we issued this miscellaneous material on a budget basis, a scheme suggested by the Alexander Hamilton Institute during a correspondence on this subject. Such items as string, glue, insulating varnish, tape, solder, paste, etc., are issued to the shop in standard quantities once or twice a month and the foreman makes an estimate of the "budget" material on each job and marks it on his report. Whenever a job takes an appreciable

Schedule for Estimating Rewinding Charges for Induction Motor Stators

That use 2 and 3-phase windings operating on 110, 220, 440 or 550-volt circuits

Horsepower	*1,800 Revolutions per Minute*	*1,200 Revolutions per Minute*	*900 Revolutions per Minute*
½	$ 22.00	$ 24.00	$ 32.00
¾	26.00	28.00	35.00
1	28.00	32.00	40.00
1½	32.00	35.00	42.00
2	35.00	40.00	44.00
3	40.00	46.00	55.00
5	46.00	53.00	64.00
7½	55.00	64.00	74.00
10	64.00	74.00	80.00
15	74.00	81.00	100.00
20	81.00	94.00	118.00
25	86.00	112.00	125.00
30	102.00	125.00	145.00
40	120.00	145.00	164.00
50	136.00	164.00	190.00
60	151.00	190.00	210.00
75	191.00	210.00	240.00
100	----------	245.00	270.00

The above prices are based on the old winding being in the frame and the scrap being retained by the repair shop. If the machines are stripped when received an additional charge will be necessary to cover the scrap value and the cost of redesigning the windings.

Wound Rotors.—The above prices are for rewinding the *stator only.* On slip-ring motors or other types of motors with wound rotors the cost of rewinding the *rotor only* is approximately the same as rewinding the stator.

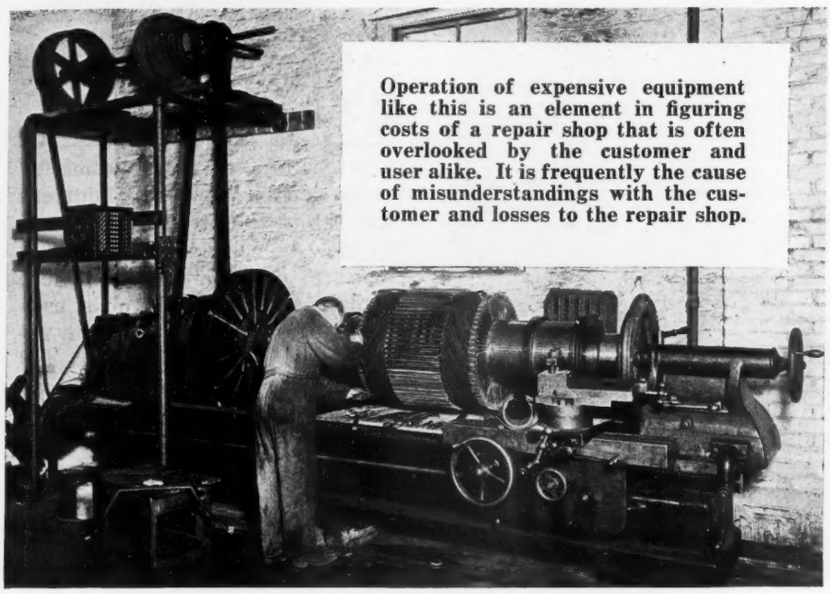
Squirrel-Cage Rotors.—On squirrel-cage rotors, the joints between rotor bars and end rings quite frequently get burned. The cost of acetylene welding these joints, turning and rebalancing rotor varies considerably with different types. An approximate cost for this work is between 15 and 20 per cent of the stator rewinding price.

Bearings.—Bearings in motors range all the way from the cheap, die-cast composition factory bearing to the special bronze and split babbitt bearings. An approximate cost *per bearing,* including taking out the old bearing and installing the new one, will be 7½ to 10 per cent of the stator rewinding price.

High-Voltage Windings.—Stators above 550 volts take a special insulation and will vary considerably in cost with different makes. The cost of rewinding 2,300-volt stators will average 20 to 25 per cent higher than the listed prices. Above 2,300 volts each job will be priced specially.

Direct-Current Armatures.—It is difficult to make a schedule of prices for rewinding of direct-current armatures, as there is considerable variation in different makes. However, the above schedule will be approximately correct for rewinding *modern* direct-current armatures, exclusive of any repairs to commutators.

Single-Phase Rotors and Stators.—There are so many varieties of single-phase motors on the market that the cost of rewinding each type must be estimated separately. The above schedule will, however, serve as a rough guide when it is remembered that a single-phase motor is about 50 per cent larger than a three-phase machine of the corresponding rating.



Operation of expensive equipment like this is an element in figuring costs of a repair shop that is often overlooked by the customer and user alike. It is frequently the cause of misunderstandings with the customer and losses to the repair shop.

amount of this miscellaneous material, a regular requisition would be issued. The "budget" scheme is simply used for the small accounts.

In the February, 1922, issue of INDUSTRIAL ENGINEER a schedule of repair prices was published. A similar schedule of rewinding prices accompanies this article, which has been worked up from the costs of several shops and used where estimates and quotations are required on a repair job. Such a schedule can be depended upon, however, only for an average cost on a straight rewinding job on a standard machine, since costs will vary with different ages, makes and types of motors. For the later designs of polyphase stators this schedule of prices will check fairly closely when the stator dimensions and the winding specifications do not differ widely. In the case of old alternating-current machines and practically all direct-current machines, however, there will be a considerable variation in specifications of windings for the same horsepower rating and the same speeds.

One large repair shop has attempted to get around these variations by using a set of curves giving rewinding costs based upon diameter and length of core. This is a step in the right direction, but has the disadvantage that it requires dismantling the motor to give a price which is out of the question in most cases where the customer 'phones or writes in for a hurry-up quotation, giving nameplate data only.

Another factor which neither this scheme nor the horsepower-speed prices take into account is the size, number and shape of slots, which are really the determining factors in the labor cost of rewinding.

Several months ago, in checking some winding costs, I ran across an extreme case of cost variation in this regard. This particular motor was rated at 10-hp., 900-r.p.m., 220-volt elevator duty which would correspond to about a 7½-hp. continuous rating. The labor cost of this machine was extra low, running about the same as a 3-hp., 1,800-r.p.m. motor. At first it was thought an error had been made in the labor cost records, but these were checked and found correct. Further investigation disclosed the fact that there were but 48 coils where ordinarily there would be 72 or 96 in a machine of this rating. In addition, mush coils were used with open slots instead of the customary partially closed slots. This is just a sample of the many things that make it dif-

Schedule of Rental Rates for Generators, Motors, Transformers and Meters Used for Temporary Service

D.C. AND A.C. GENERATORS 110, 220 OR 550 VOLTS			D. C. MOTORS, 110, 220, OR 500 VOLTS—STANDARD SPEEDS			A. C. SQUIRREL CAGE, MOTORS*, 110, 220, OR 440 VOLTS—2 OR 3 PHASE STANDARD SPEEDS			A. C. MOTORS, SINGLE PHASE—STANDARD SPEEDS		
Kw. Rating	One Month or Less	Each Succeeding Month	Hp. Rating	One Month or Less	Each Succeeding Month	Hp. Rating	One Month or Less	Each Succeeding Month	Hp. Rating	One Month or Less	Each Succeeding Month
3	$ 10.00	$ 6.00	1	$ 6.00	$ 3.50	1	$ 6.00	$ 3.50	1	$ 8.00	$ 5.00
6	12.00	7.50	2	7.50	4.50	2	7.50	4.50	1½	9.00	6.00
8	15.00	9.00	3	9.00	5.50	3	9.00	5.50	2	11.00	6.50
10	18.00	10.00	5	11.00	6.50	5	11.00	6.50	3	12.00	7.50
12	20.00	12.00	7½	13.00	8.00	7½	13.00	8.00	5	15.00	9.00
15	25.00	15.00	10	15.00	9.00	10	15.00	9.00	7½	20.00	12.00
20	30.00	18.00	15	18.00	10.00	15	18.00	10.00	10	25.00	15.00
30	37.50	22.50	20	20.00	12.00	20	20.00	12.00	15	30.00	18.00
40	45.00	27.00	25	25.00	15.00	25	25.00	15.00	20	40.00	24.00
50	55.00	33.00	30	30.00	18.00	30	30.00	18.00	25	45.00	27.00
60	65.00	39.00	35	35.00	21.00	35	35.00	21.00			
75	85.00	51.00	40	40.00	24.00	40	40.00	24.00			
100	120.00	72.00	50	50.00	30.00	50	50.00	30.00			
150	180.00	108.00	75	75.00	45.00	75	75.00	45.00			
200	240.00	144.00	100	100.00	60.00	100	100.00	60.00			

The rental price on all machines includes rails, or base, starting rheostat or compensator and such pulley as we can furnish from our stock. Alternating current motors up to and including 5-hp. are furnished without starters.

Rental on slow speed and on low voltage machines on application. Rental on transformers, $1.50 per kw. first month; 75c per kw. per month thereafter.

The rental on wattmeters and ammeters is a minimum charge of $5.00 for first month or lesser period on instruments valued at $30.00 or less. Rental on larger sizes on application.

*For slip ring motors the prices are 25 per cent higher than those listed.

What the vault is to a jeweler like Tiffany, this storeroom is to the repair shop. When open to everyone it's a liability; but properly guarded, it's the control on avoidable losses, and waste.

ficult to make up any winding cost schedule.

In the case of direct-current and single-phase motors, there is even a greater variety of types and construction, especially with direct-current, as they represent such a wide span of years in design.

We have the same variation to contend with in the cost of bearings. For example, a certain die-cast white metal bearing can be purchased for $1.06, while a similarly rated motor of another make has a complicated split babbitted bearing which will take almost a day's time for a machinist to babbitt and machine, besides using an amount of babbitt which alone would cost more than the die-cast bearing. Between these extremes is the bronze bearing machined to order from cored bushing stock.

In our work we use the accompanying schedule for approximate quotations when these are required and put each job through on a cost-plus basis and bill accordingly. We have found that a customer is ready to pay for a quality job that can be depended upon and stands up in service. When work is done on this basis and the confidence of the customer is secured, prices are seldom called for in advance. Moreover, so much of the work of a small repair shop is only the replacing of a few coils or the location and correcting of winding troubles that the big problem is the working out of an equitable method for charging for material and labor so as to include the proper amount of overhead and a reasonable profit. This is largely a matter of experience and good judgment where skilled men are employed.

In view of the wide variation in analysis of costs, however, I believe that a discussion of methods used and the equipment employed in repair shops would be of interest and profit to all concerned, and I hope that readers of INDUSTRIAL ENGINEER will present their views on the subject for publication. I would particularly welcome comments on the viewpoints which I have here presented.

Coil making is an art that can be greatly refined when suitable machines are provided. Good coils properly formed not only make a good winding job possible but save a lot of the time of the man who inserts them.

The Coil-Windin' Man

Here's a little jingle that is just as true in fact as it is in rhyme.

When motors are stoppin',
Wherever he is,
He's right there a-hoppin',
To keep 'em in biz;
He knows every part of
A motor's inside,
An' harks to the heart of
Her hummin'—with *pride!*

No matter what *make* of a motor it be,
He knows all about it—from A to Z;
An' if it needs *fixin'*—well, fix it he *can*—
He's *some* motor-fixer—the coil-windin' man!

He's always a-bustle,
With "ginger" an' "snap";
His job's to keep motors
From goin 'to "scrap,"
He turns his wise eyes on 'em—
And grins a broad grin—
You bet he is *wise* to 'em—
Outside an' in!

No matter what's *ailin'* them—take it from *me,*
He'll *fix* it—whatever the trouble may be!
He's *some* little fixer, and if *anyone* can
Make good on a job—it's the coil-windin' man!

If you will paste this up in your repair shop, I think it will serve as a little recognition that is due your coil-winding man. It is presented with acknowledgment to the author, James Edward Hungerford, Los Angeles, Cal.

Practical Pete

WHAT IS INCLUDED in maintenance work? How is it handled in different plants? How often are inspections made on different equipment? What are the most frequent causes of motor failures? What is the character and amount of parts and supplies kept in stock by different companies for maintenance work? These and some fifteen other points in the operation and maintenance of systems in 74 industrial works are answered in detail in this article. It's the first analysis of this kind that has been made heretofore and will be a regular feature of every January issue of Industrial Engineer.

This is a Report on

Practice in Maintenance Work

Showing How 74 Companies Handle Inspections, Repairs and Maintenance Supplies

By E. H. HUBERT
Associate Editor, Industrial Engineer

Work in the repair shops is curative and only one phase of maintenance—adequate inspection is preventive and reduces extensive repair costs to a minimum.

MAINTENANCE of electrical and associated mechanical systems in industrial works is a broad subject, as long and as wide as the area covered by the structures in which the work of production is carried on, as complicated as the equipment and processes that are used. It is less organized than the work of production at machines, yet of equal importance and an essential element in a program of production at the most economical cost per unit of product made.

In this article an analysis is made of maintenance procedure and practices in 74 works along the line of power service from the main switchboard along feeder and distribution circuits, through control equipment and motors, through bearings, pulleys, belts, shafting and speed changing equipment and other parts of the mechanism of power service operated by the motor down to the pulley or spindle of the machine engaged in a process of production. In this line of power service is also included those elements of service to machines and departments of production represented by material handling equipment such as conveyors, elevators, cranes, electromagnets, electric storage battery trucks and the like—equipment that is operated by motors or electrical energy and renders a service that fits in between steps of specialized production at machines.

The maintenance procedure embraces work done on the job in this line of power service and that which requires a specially equipped repair shop for making extensive repairs or rebuilding the equipment.

The seventy-four industrial works that are embraced in this report were chosen among those that represent large area, devoted to production processes and show a pride in good operating methods and good products. They range in size from 4,500 motors with a total rating of 45,000 hp. and use 11,000,000 kw.-hr. per year in electrical energy, to rather small plants where the nature of the product requires a relatively small amount of power. There are thirty-one plants in the group that use over one million kw-hr. per year, which will be called in this article the class A division. There are eleven that use over 500,000 kw.-hr. and will be called the class B division. Those that use less than 500,000 kw.-hr. will be called the class C division. The works all together represent a total installation

How Maintenance of Electrical and Associated Mechanical Systems Is Handled in 74 Works

IN THIS TABLE an analysis is presented of the maintenance, repair and stock-keeping practices of industrial works that cover a large floor area with electric service in all departments and also operate cranes, conveyors, elevators and material handling equipment.

AN INTERPRETATION of the figures and statements is given on pages 27, 30, 31 and 36 under the following headings: Motor failures, repair and inspection organizations, numbers of men in inspection crews, frequency of inspection and overhauling, amount of

Plant No.	GENERAL PRODUCTS MADE	Power Used	CONNECTED MOTORS								LAMPS			MOTOR FAILURES			Repair Dept.	
		KW-Hrs. Per Year	Number of Motors	Total H. P.	Voltage	A. C. or D. C.	Largest Size, H. P.*	Smallest Size, H. P.*	Number of Motors Under ½ H. P.*	Kind of Drive* (b) Belt; (c) Chain; (d) Gear, or Direct.	Number	Average Size, Watts	Renewals Per Year	Failures Per Year	Burnouts That Require Rewinding	Chief Cause of Motor Failures	Do You Repair and Rewind All Electrical and Mechanical Equipment?	Do You Make Your Coils?
	BRASS AND BRONZE PRODUCTS																	
1	Plumbing and gas goods	1,800,000	174	1230	440	A.C.	40	1/6	85	141b, 1c, 32d.	1600	60	2000	½	½	Starting coil burned out on single phase	Partly	Yes
2	Grease cups, oiling devices	199,000	17	850	220	A.C.	75	½	3	9b, 8d.	700	100	300	0	0		No	No
3	Cast brass, bronze, aluminum		14	190	220	A.C.	20	½	6	14b.	160	60	40	¼	0	Worm bearings	Yes	No
4	Brass and silver pens and pencils	710,400	172	1557	220	A.C.	200	1/16	100	140b, 32d.	1466	25 to 200	1058	24	5	Small motor on direct drive	No	No
5	Brick and tile	432,000	8	365	460	A.C.	250	7	0	5b, 2c, 1d.	100	40	200	0	0		No	No
6	Brick and tile	420,000	12	345	440	A.C.	150	5	0	6b, 5d, 1c.	100	40	100	4	2	Dirt and worn bearings	No	No
7	Cement, white portland	3,000,000	39	1480	440	A.C.	150	2	2	29b, 7c.	450	60	900	Few	3	Bearing, fuse or breaker failing	Yes	No
8	Chemicals and dyes		72	1020	220	A.C.	40	½	20	72b.	600	40	700	1	1	Worn bearing	Partly	Yes
9	Coal mining, bituminous	4,350,000	325	2000	2200	A.C.	290	⅜	160		4000	60		300	125	Bearings, oil dust	[2]Yes	No
					440	A.C.												
					250	D.C.												
10	Coal mining, bituminous	600,000	14	441					300					5	1	Grease, low voltage	No	No
11	Coal mining, bituminous		14	250	250	D.C.	50	2	4	12d.	75	60		5	5		No	No
12	Copper smelting	500,000	18	444	2200	A.C.	150	5	0	11b.							Yes	No
					220													
13	Electric generators, turbines, Motors and small products	11,000,000	4500	45,000	600	A.C.				95%d.						Metal chips and cutting liquid	Yes	Yes
14	Electric generators, turbines, Motors and small products		975	4,500	230	D.C.	300	¼	400	465b, 40c, 468d.				15	6	Overloads	Yes	Yes
15	Electric generators, turbines, Motors and small products	960,000	161	1,250	220	A.C.	150	1/6	20	100b, 61d.	1400	86	1700	8	2	Single phasing	Yes	Yes
16	Electric generators, turbines, Motors and small products	240,000	120	350	110													
					220	A.C.	20	1/10	90	90b, 30d.	570	50–100	1200	4	2	Probably overloads	Partly	Some
17	Electric generators, turbines, Motors and small products	120,000	125	500	220	Both	100	1/6	90	70b, 1c, 44d.	275	75	125	2	½	Dirt and oil	Yes	Yes
18	Electric lifting magnets and meters	85,000	24	142	110 to 440	AC & DC	30	¼	14	12b, 12d.	175	40-60	250	0	0		Partly	Yes
19	Electric motor-generators	26,000	8	42	220	A.C.	7½	½	5	8b.	36	100	12	¼	0		Yes	Yes
					220	D.C.												
20	Electric meters	75,000	30	500	440	A.C.	30	½				75		1	1		No	No
21	Fertilizer, commercial	291,200	25	585	220	A.C.	125	5	0		150	50	300	1	1		No	No
22	Fruit cannery (total of 6 plants)[6]	155,000	98	485	220	A.C.	20	1/6	48	90b, 8d.	1208	50 - 75	585	2	2	Lightning and short circuit	No	No
	IRON AND STEEL PRODUCTS																	
23	Pig iron		16	570	220	D.C.	50	3	3	4b, 12d.	380	50–300	$600	50	6	Oil creepage with coke dust	Yes	No
24	Steel castings	113,700	49	719	230	D.C.	225	½	32		270	300	70	19	13	Grounds	Yes	No
25	Hoists, locomotives, coal and cement machinery, fans	1,000,950	208	2950	440	A.C.	225	½	32		980	200	245	54	22	Grounds and oil	Yes	No
26	Steel plates	7,981,441	726	16,172	250	D.C.	200	⅛	150	mostly d.	2090	200	4971	400	60	Oil, defective insulation, mech. failures, overloads	Yes	No
27	Steel castings	7,218,774	391	7340	240	D.C.	100	¼	37	150b.			8587	105	42	Shorts in commutator, grounds	Yes	No
28	Steel castings	3,996,000	72	630	220	A.C.	150	½		28b, 46d.		50–200	$350	2	1/5	Worn bearings, A.C., Oil, D. C.	Yes	No
29	Castings, machinery	2,000,000	140	2391	440	A.C.	225	½	30	5b, 1c, 134d.	623	200	1250	82	17	Grounds	Yes	Yes
30	Locomotive stokers and coal pushers	721,000	120	1200	220	A.C.	100	⅛		110b, 1c, 9d.	900	100	700		6	Cleaning neglected	No	No
31	Machinery	1,400,000	1000	8825	440	A.C.	150	1/6	600	790b, 20c, 190d.	10,000	40	15,000	150	90	Burn outs	Yes	No
32	Automobile frames	2,448,000	281	4049	440	A.C.	150	¼	90	210b, 5c, 66d.	2130	200	1200	25	5	Single phasing, fumes	Yes	Yes
33	Valves, pipe fittings, etc.	5,000,000	233	3268	220	D.C.	720	1/10	100	156b, 2c, 75d.	3400	75	7500	3	2	Overload, commutator & iron dust	Yes	Yes
34	Gate valves	120,000	13	297	220	A.C.	50	1	2	10b, 3d.	200	50-75	144	0	0		No	No
35	Nuts and bolts	2,048,000	330	3698	220	A.C.	200	⅛			2570	60	5098	100	24	Insulation failure	No	No
					230	D.C.						200 to						
36	Auto and bicycle accessories	3,400,000	200	3000	440	A.C.	100	½	50	150b, 3c, 47d.	800	500					Partly	No
37	Rifles and pistols	900,000	275	2500	220	A.C.	150	¼	12	275b.	600	60	4	5	2	Single phasing	[1]Yes	Yes
38	Typewriters	375,000	75	443	230	A.C.	50	⅛	30	65b, 10d.	1400	40 - 75	2400	0	0			No
39	Leather, sole		38	662	440	A.C.	100	1	9	35b, 3d.	520	50	250	3	1	Insulation failure	Partly	No
					110	D.C.												
40	Leather, sole	1,948,400	98	1477	550	A.C.	65	¼	16	58b, 34c, 6d.		50	1784		1	Moisture, hot bearing	Partly	No
41	Leather, heavy upper	1,500,000	150	700	440	A.C.	75	½		37b, 110c, 3d.	500	100	500	8	8	Moisture	No wd	No
42	Leather shoes, women's and children's	415,000	118	205	220	A.C.	20	½	100	25c, 38g, 55d.	700	40	750		0	Worn bearing	No wd	No
43	Leather boots and shoes	360,000	40	325	550	A.C.	30	¼	21	25b, 15c.			300		30		No	No

maintenance stock, and responsibility for maintenance, production and non-interruption of service. The data in the tables has been compiled from individual reports from seventy-four companies in a wide variety of industries.

In some cases special reference was made in the reports received to details of practices or explanations offered covering the figures given. The following notes explain such items and bear marks in the table corresponding with the small reference figures shown here:

* In some cases these figures have been estimated.
[1] No heavy equipment repaired.
[2] Machine operator is responsible.
[3] Locomotive motors.
[4] Magnet Wire.
[5] Keep one month's supply of all materials.
[6] Total of figures for six plants each having from 51 h. p. to 100 h. p. installed in motors.
[7] Surplus from war time.
[8] Safety inspectors only.
[9] 1,000 links and 100 refillable fuses.
[10] No rewinding done.
[11] Two complete bearings per motor kept in stock.

INSPECTION WORK					OVER-HAUL'NG		MAINTENANCE SUPPLIES KEPT IN STOCK													RESPONSIBILITY FOR MAINTENANCE	
	Frequency of Inspection Weeks																				
How Many Men Employed as Inspectors?	Motors	Control	Cranes	Material Handling Equipment	How Often Is Equipment Thoroughly Overhauled?	When Is Overhauling Done?	Wire	Brushes	Babbitt, Lbs.	Solder, Lbs.	Tape, Rolls	Oil, Bbls.	Conduit and Fittings	Fuses	Lamps	Reflectors	Belts	Pulleys	Chains	Gears	Title of Man in Charge of Maintenance	Is He Also Responsible for Production and Non-interruptions of Service? If not, Give Title of Man in Charge of This Work
0	.....	.....	.....	.....	Yearly	Dec.	.....	.....	...	...	.....	...	.....	.....	.....	...	.....	.....	.....	.....	.....	.....
0	4	.....	.....	.....	.....	.....	2000′	Few	...	...	25 rolls	1	.....	100	350	24	1500′	200	.....	.....	Supt.	.....
1	1	1	.....	.....	6 mo.	Aug. Feb.	0	Set	0	0	2 lb.	1	0	50	100	0	0	50	0	0	Asst. Supt.	Yes
2	.....	.....	.....	4	Yearly	Jan. 1.	2000′	.....	25	25	5 lb.	1	3000′	2 mo.	2 mo.	....	1 mo.	1 mo.	.....	.....	.....	.....
0	See[2]	.....	.....	.....	Yearly	Fall	0	Set pr. mtr.	0	0	.....	....	None	.....	75	0	0	0	Links	0	Master Mechanic	Supt.
0	1	.....	.....	.....	.....	As needed	Little	5	0	0	Few rolls	1	None	Few	1 case	0	0	0	0	0	Asst. Gen. Mgr.	Yes.
3	Daily	Daily	.....	Daily	.....	As needed	.....	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	Supt.	Yes.
2	2	2	2	.....	.....	As needed	400′	18	50	20	24 rolls	½	150′	12 ea.	100	12	1000′	20	.....	.....	Elec. Engr.	No.
12	1	.....	.....	.....	.....	As needed	[4]600 lb.	500	...	100	50	....	150	.....	.....	.....	.....	.....	.....	.....	Elec. Engr.	Gen. Mgr.
1	[3]Daily	.....	.....	Daily	.....	As needed	.....	.....	...	...	20 lb.	15	.....	.....	.....	...	.....	.....	.....	.....	Machine boss.	Yes.
0	.....	.....	.....	.....	.....	.....	.....	.....	50	20	50 lb.	....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	.....	As needed	.....	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	Electrician	Supt.
3	.....	.....	4	.....	.....	As needed	.....	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	Foreman elec.main.	Not prod.
....	.....	.....	.....	.....	.....	As needed	.....	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	Maint. Supervisor	Yes.
2	.....	.....	1	.....	.....	As needed	.....	.....	...	...	.....	....	.....	.....	500	5	.....	.....	.....	.....	Electrician	Supt.
1	4	.....	.....	.....	.....	As needed	0	0	0	0	0	1	Small amt.	400	150	100	300′	25	.....	.....	No title	Yes.
1	26	26	26	.....	.....	Never	.....	.....	...	...	.....	....	Considerable	.....	.....	...	.....	.....	.....	.....	Supt.	Yes.
2	1	1	1	.....	.....	As needed	100′	Set pr. mtr.	50	50	25 lb.	3/5	100′	300	60	0	125	0	0	0	Supt.	Yes.
1	.....	.....	.....	.....	.....	.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Supt.	Yes.
1	52	.....	.....	.....	.....	As needed	.....	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....
1	1	1	.....	Daily	6 mo	Winter & S	.....	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	Supt.	Yes.
0	Daily	.....	.....	.....	Yearly	Spring	0	0	30	5	9 rolls	7/10	0	143	111	0	0	0	0	0	No title	Yes.
3	Twice daily	Twice daily	Twice daily	Twice daily	3 yr.	.....	2000 lb.	3 sets pr. m	100	25	25 lb.	3	500′ 300 fitgs.	80	168	10	.....	.....	.....	75	Elect., M. M. and Steam Engr.....	Yes.
5	1	1	2	4	.....	As needed	3000′	70	...	25	25 lb.	....	500′ 200 fitgs.	25 ea. size	24 ea. size	....	.....	15	.....	spare	.....	.....
6	½	½	.....	.....	.....	When poss	55,000′	5858	...	200	2000 lb.	....	.....	3000	2104	50	.....	.....	.....	1000	.....	.....
6	Daily	Daily	Daily	.....	.....	As needed	2000′	Large no.	500	50	200 lb.	5	400′	.....	336	0	500′	0	.....	.....	.....	.....
1	Daily	10	1	.....	W'kly	Week end	Some	1 or 2 sts.	25	15	10 lb.	1	(Few angles) and elbows)	110	100	Few	100′	Few	2	2	Elec. and Mach'st	Master Mech.
5	Daily	1	½	.....	.....	As needed	400 lb.	330	50	20	60 lb.	1	400′	.....	700	0	100′	0	0	60	Supt. Light, Heat and Power.....	Prod. Supt.
2	1	1	1	.....	.....	As needed	See[5]	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	Shop Engr.	Supt.
3	4	4	4	4	Yearly	Cont.	$1500	$20	...	...	$100	2	$200	200	4000	0	.....	.....	.....	.....	Works Mgr.	Yes.
....	1/7 &2	1/7 &2	1	1/7& 1	.....	As needed	1500′	200	300	100	50 lb.	10	1500 pieces	500	250	0	2500′	150	0	0	Master Mech.	Yes.
3	Daily	Daily	Daily	....	.....	As needed	.....	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	Supt. of Maint.	General Supt.
....	1	17	.....	.....	.....	.....	0	0	10	0	3 rolls	1/5	0	36	48	0	0	3	0	0	Works Mgr.	Yes.
....	Daily	Daily	Daily	Daily	.....	As needed	.....	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....
0	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	....	.....	.....	.....	...	.....	.....	.....	.....	Plant Engr.	Supt.
....	.....	.....	.....	16	Yearly	.....	2000′	100	200	200	[7]400 lb.	1	2500′	10,000	1500	1000	.....	500	0	0	Electrician	Prod. Engr.
2	4	4	.....	4	.....	As needed	100lbs.	0	20	10	5 lb.	1/10	None	50	60	12	.....	Few	0	0	Wks. Engr.	Yes
[8]4	2	2	1	.....	.....	.....	2500′	St. pr. mtr.	200	25	15 lb.	1	800′	[9]1000	100	....	500′	100	150′	25	Plant Engr.	Supt.
0	1	4	4	4	.....	.....	10000′	.....	...	25	50 rolls	3/5	5000′	$700	250	...	.....	50	.....	.....	Chief Engr.	Yes.
2	1	1	.....	1	Yearly	.....	1000′	.....	200	50	25 lb.	5	0	500	500	25	1000′	50	50	50	Elec. Engr. & Mast. Mechanic.....	Yes.
1	4	.....	.....	2	6 mo.	Apr. Oct.	3500′	.....	10	20	10 lb.	2	.....	.....	200	40	500′	25	0	0	Engr.	Yes.
1	1	1	.....	.....	.....	As needed	10′	1 set	50	5	5 lb.	....	.....	100	400	....	.....	.....	.....	.....	Chief Engr.	.....

This Table is continued from pages 28 and 29

Plant No.	GENERAL PRODUCTS MADE	Power Used	CONNECTED MOTORS								LAMPS			MOTOR FAILURES			Repair Dept.	
		KW-Hrs. Per year	Number of Motors	Total H. P.	Voltage	A. C. or D. C.	Largest Size, H. P.*	Smallest Size, H. P.*	Number of Motors Under 5 H. P.*	(b) Belt; (c) Chain; (d) Gear, or Direct,	Number	Average Size, Watts	Renewals Per Year	Failures Per Year	Burnouts That Require Rewinding	Chief Cause of Motor Failures	Do You Repair and Rewind All Electrical and Mechanical Equipment?	Do You Make Your Coils?
44	Leather, substitute heeling and fibre	809,000	9	375	2500 250 440	A.C. A.C.	300	7½	0	8b, 1d.	30	200–50	75	0	0		No	No
45	Lumber, sash, doors, boxes	3,000,000	247	6484	220 110	A.C. D.C.	150	½	....	210b, 1c, 46d.	.....	50–400	2000	0	0	Clutch failure, left in starting pos.	Partly	No
46	Lumber, all kinds	488,670	23	525	440	A.C.	150	2	2	22b, 1g.	96	60	75	½	½	Overload and vertical drive	No	No
47	Lumber	.....	31	422	.....	A.C.	35	5	.....	.....	500	50	200	2	1/15	Overload	No wd	No
48	Meat products	300,000	50	375	220	D.C.	25	⅛	25	12b, 3c, 35d.	2000	60	.....	25	2	Moisture	No	No
49	Meat, slaughtering	750,000	15	350	220	A.C.	125	2	3	11b, 1c, 3d.	500	75	500	3	3	Moisture	No	No
50	Paper	4,572,000	86	1915	550	A.C.	400	¼	35	67b, 19d.	1400	25-60	5000	2	0		Partly	No
51	Paper, fine writing	1,700,000	28	806	600	A.C.	100	5	0	6b, 22d.	.....	.....	.....	2/5	2/5	Dirt, oil, chemicals and water	No wd	No
52	Paper, writing	960,000	10	428	2200 220	A.C.	200	½	3	9b, 1d.	125	25	.....	Few	0	Wear of fingers in starters	No	No
53	Paper, rope and jute	652,000	18	200	220	A.C.	100	¼	4	18b.	290	40	1650	1	....		No	No
54	Pencils	1,096,000	54	1100	230	D.C.	60	½	....	48b, 6d.	1100	40	800	1/3	¼	Detoriation of insulation	No	Yes
55	Railroad shop	1,070,060	204	2555	230	D.C.	100	1/5	30	67b, 14c, 123d.	18,000	60	25,000	20	6	Grounded coils and power fluctuate	Yes	Yes
56	Rubber tires	1,800,000	50	1650	440	A.C.	600	½	....	15b, 3c.	500	100	800	1	1	Overload	No	No
57	Rubber tires and other products	1,322,000	29	927	440 230	A.C. D.C.	250	1/30	16	21b, 1c, 7d.	244	100	8	4	1	Worn bearing	No	No
58	Rubber tires and tubes	400,000	15	385	.....	D.C.	150	¼	6	6b, 2c, 9d.	100	200	170	5	2	Worn out	No	No
59	Rubber boots, shoes and clothing	.....	93	1350	550 110	A.C.	500	1/10	....	85b, 8d.	2000	40	2000	3	1	Water	No	No
60	Soap, all kinds	.....	200	1400	440 220	A.C.	100	⅛	87	130b, 7c, 63d.	500	60	125	10	10	Low voltage	No	No
	TEXTILES																	
61	Catton goods	8,000,000	950	9000	220 550 2300	A.C.	200	½	350	.....	10,000	50-75	.....	10	10	Wear on windings	Yes	No
62	Cotton yarns	2,250,000	28	1100	220 2300	A.C.	250	5	0	.....	1000	25–100	750	0	0	Lightning and surges	M'tly	No
63	Wool tops	2,048,410	38	.....	440	A.C.	100	3	5	6b, 25c, 7d.	427	40–100	275	1	1	Bearings worn	No	No
64	Woolen goods	544,000	63	500	240	A.C.	15	1	4	58b, 1c, 4d.	1000	50-400	300	2	½	Worn bearings, flyings	No	No
65	Silks, broad	580,000	576	650	220	A.C.	20	1/40	515	11c, 500d.	2576	60	1160	17	6	Overload due to faulty adjustment	Yes	Yes
66	Silks, broad	68,300	149	60	220	A.C.	1	1/3	140	20b, 120d.	350	40	100	⅛	⅛	Lack of oil	Partly	No
67	Tobacco, plug and cut	180,000	26	252	440	A.C.	20	½	2	26b.	500	75	100	0	0		No	No
68	Electric generators and motors	8,720,000	3500	19000	230 440	D.C. A.C.	700	1/50	290	1900b, 100c, 1300d	15000	75	17000	2000	200	Shorted and grounded con. and windings	Yes	Yes
69	Yarn and cloth	29,000,000	1577	17812	.....	.....	.....	.....	.....	.....	13,000	60	1300	Few	Few	Lightning	Yes	Yes
70	Building materials	2,184,000	466	8484	125 110 220 440	D.C. A.C.	150	⅛	55	.....	6000	60	1200	12	2	Poor machine operation	Yes	Yes
71	Electric trucks	450,000	407	2400	440	A.C.	400	¼	73	450b, 100c, 82d	1875	200	600	30	10	Dust and dirt	Yes	Yes
72	Cotton cloth	4,660,600	81	1821	110 550	D.C. A.C.	75	⅛	8	All b.	810	100	1050	2	Few	Low voltage and overloads	No	No
73	Floor and wall tile	450,000	92	775	220 110	A.C.	25	1	20	10b, 70d. 80%b, 15%c, 5%d.	600	60	500	14	4	Low voltage	Yes	No
74	Shoes	1,200,000	649	1877	220	A.C.	100	1/10	560		6000	25	2500	5	1	Bearings and grounds	No wd	No

of 209,925 hp. in 21,244 motors that use over 147,000,000 kw.-hr. of electrical energy per year. The average consumption per plant is about 2,000,000 kw.-hr. and the average consumption per installed horsepower is about 700 kw.-hr. Thirty-five of the plants have over 1,000 hp. installed in motors.

Motor Failures.—Of the causes for motor failures, worn bearings and moisture were responsible for the largest share on alternating-current motors. On such machines the causes of failures were reported as follows: Worn bearings, 12; moisture, 5; oil, 1; chemicals, 1; fumes, 1; dirt, 6; overload, 5; fuse blown on one-phase (single-phasing), 3; grounds, 6; starter fingers burned, 1. On direct-current machines, oil and commutator troubles caused eight failures; overloads, 3; grounds, 3; dust, 1. Out of 1,534 failures, 504 motors required rewinding. The highest percentage of failures was 50 on 16 motors in a pig-iron furnace company which is plant No. 23 in the table. The motors are 220-volt, direct-current. Oil creepage and coke dust are responsible for the large number of failures. Due to the difficulty of operating under such conditions, the equipment in this plant is inspected twice a day. Next to this record comes a failure of 300 in 325 motors in a coal mine which is No. 9 in the table. These failures were on 220-volt and 440-volt alternating-current motors and on 250-volt direct-current locomotive motors. They were caused by worn bearings, oil and dust. Another case shows 82 out of 140, alternating-current, 440-volt motors in a plant for iron and steel castings and machinery reported as No. 29 in the table. This was in spite of daily inspection by fire inspectors. Several of the plants making heavier iron and steel products showed a large percentage of failure which reflects the particular conditions in these plants. A meat-

See explanatory notes on page 29

INSPECTION WORK					OVER-HAUL'NG		MAINTENANCE SUPPLIES KEPT IN STOCK													RESPONSIBILITY FOR MAINTENANCE	
How Many Men Employed as Inspectors?	Frequency of Inspection Weeks				How Often Is Equipment Thoroughly Overhauled?	When Is Overhauling Done?	Wire	Brushes	Babbit, Lbs.	Solder, Lbs.	Tape, Rolls	Oil, Bbls.	Conduit and Fittings	Fuses	Lamps	Reflectors	Belts	Pulleys	Chains	Gears	Title of Man in Charge of Maintenance	Is He Also Responsible for Production and Non-interruptions of Service? If not, Give Title of Man in Charge of This Work
	Motors	Control	Cranes	Material Handling Equipment																	
	Daily	Daily	.....	.....	.....	Asneeded	0	2 sets 50	...	...	.....	1	.....	50	25	.....	.50′	.....	.....	.....	..Master Mech.	Not for prod.
2	Daily	Daily	.....	.....	.....	As needed	400′	Set pr. mo.	...	...	35 lb.	2	.....	.....	130	Few	.....	9	.....	.....	.....	.....
1	½	12	.....	.....	3 mo.	.....	600′	.....	...	4	6 rolls	2	Some	24	100	....	500′	10	.....	.....	Engr.	.....
1	1	.....	.....	.....	.....	As needed	300′	.....	50	10	5 lb.	1	None	400	200	0	600′	20	.....	.....	.....	.....
2	1	.....	.....	.....	.....	As needed	Some	100	...	50	10 lb.	1/5	Small stock	200	350	100	.....	25	.....	.....	Electrician	Supt.
0	Daily	26	.....	1	.....	As needed	.....	.....	20	10	6 lb.	1/5	200′	4 ea.	200	3	5 ea.	0	links	0	No title	Yes.
2	1	1	.....	1	.....	As needed	500′	Set pr. mo.	0	25	100 lb.	3/5	1800	2000	1000	50	0	0	0	0	Mgr. of Maint.	Mgr. of Prod.
1	Daily	Daily	.....	Daily	Yearly	.....	5000′	100	500	25	15 lb.	5	300′	150	200	25	1000′	100	75	100	Asst. Supt., Mast. Mech.	Yes.
1	52	.....	.....	.....	Yearly	July															Mast. Mech.	
1	Daily	.....	.....	.....	Mthly	.....	0	Few	100	10	.....	0	0	Few	Few	0	0	0	0	0		No.
2	.....	.....	1	.....	Yearly	.....	500′	.....	0	10	10 lb.	1/10	.....	200	300	25	0	4	0	0	No title	Yes.
4	1	1	1	1	.....	As needed	Little	Few sets	...	...	.....	1	Few	.....	.....	.....	.....	.....	.....	.....	Man in Elec. Dept.	Man in Mech. Dept.
1	1	1	.....	.....	.....	As needed	500′	2 sts pr. mo	100	50	500 rolls	1/5	$2500 stock	510	5000	200	400′	12	1	6	.....	.....
1	1	4	.....	.....	Yearly	December	0	Set pr. mo.	200	25	10 lb.	1/5	None	.....	12	0	0	0	0	0	Mast. Mech.	No.
0	Daily	1	.....	.....	2 yrs.	.....	1000′	6 sets	50	10	.....	1/3	4000′	100	100	80	.....	24	.....	.....	.....	.....
1	1	4	.....	.....	6 mo.	Jan. & Jul	.....	Few pr.mo.	100	25	10 rolls	1/5	$150	.....	50	25	Little	.....	.....	.....	Mast. Mech.	Factory Mgr.
															500							
7	1	1	.....	1	Yearly	Winter	1000′	Set pr.mac.	100	50	25 rolls	2	$500	250	250	100	500′	100	$1000	$1000	Mast. Mech.	Yes.
6	1	4	.....	.....	Yearly	.. ..	2000 lb.	Set pr.mot.	See n	100	50 lb.	10	$1000	2000	1000	200	$1000	$2000	.....	.....	Mech. Supt.	Yes.
3	1	1	.....	1	.....	As needed	.....	.....	...	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Mast. Mech.	.....
4	1	1	.....	.....	Yearly	.....	.....	.....	...	25	50 rolls	....	.....	.....	500	0	.....	25	3	0	Supt.	Yes.
1	1 & 4	0	0	4	.....	As needed	Little	1 extra set	100	10	3 lb.	....	Small supply	.....	300	0	0	.....	0	.....	No title	Yes.
6	1	1	.....	.....	2 mo.	As needed	5000′	24	0	5lb	20 lb.	1	500	$200	$200	200	.....	.....	.....	50	.....	.....
0	13	13	.....	.....	Yearly	Jan.	0	0	0	0	0	0	0	100	100	12	50′	4	0	24	Supt.	.....
1	2	.....	.....	.....	.....	As needed	0	0	Sm	Sm	2 rolls	Sm	0	50	12	....	0	Some	0	0	Engineer	Supt.
7	Daily	Daily	1	1	.....	.....	500 lb.	800	...	60	40 lb.	....	20,000′	10,000	5000	800	5500′	.....	0	0	No title	Yes
6	1	M'nly	M'nly	M'nly	Y'rly	August	.....	1 extra set	1M	250	.....	33	.....	.....	.....	.....	.....	.....	.....	.....	Supt. Mech. Dept.	Yes
5	Daily	M'nly	Daily	.....	.....	Monthly	1000 lb.	300 to 400	500	50	200 lb.	2	1000	200	1000	....	.....	.....	.....	30	....	.....
4	1	1	Daily	.....	Y'rly	1st of Yr.	1500 lb.	500	200	100	50-100lb.	4	.....	500	200	25	600′	100	15	200	Plant Engineer	Yes
3	1	Daily	.....	.....	Y'rly	Spring	Little	9 Sets	...	10	3 lb.	....	.....	..400	50	....	....	....	.....	.....	Chief Elect.	Supt.
1	1	1	.....	1	.....	As needed	0	0	500	20	12	2	0	100	100	0	0	0	150′	50	Mast. Mech.	Yes
2	1	M'nly	.....	.....	.....	.....	20,000	24	100	100	25 lb.	10	3000′	4000	1400	100	5000′	$1500	0	0	Mech. Eng.	Yes

packing plant had 25 failures in 50, direct-current, 220-volt motors, caused chiefly by moisture.

Repair and Inspection Departments. — Some interesting figures were reported regarding repair and inspection departments. The companies were asked for details of attention paid to motors, control equipment, belts, chains, gears, pulleys, and material-handling equipment including cranes, storage-battery trucks, electric hoists, conveyors. Twenty-seven companies said they repair and rewind all electrical and mechanical equipment such as mentioned. Sixteen companies have a repair department for part of their equipment; that which is not regularly repaired by the plant force is usually of large rating. Nineteen of the companies make their own motor coils. Fifty-six companies have regular inspection crews totaling 155 men. In the plants of the Class A division, all but one conduct regular inspections. In this one plant the machines have individual motor drives and the machine operators are responsible for their operation. Three of the plants in Class A division have no inspection crews as such but motors are inspected daily in two of them and weekly in the other. All the other plants, excepting seven, either have a regular inspection crew or make daily inspections. These seven make inspections at regular intervals as follows: Nos. 40 and 48, weekly; No. 2, monthly; No. 66, every 3 months; Nos. 1 and 5, yearly, and No. 11, never.

Number of Men in Inspection Crews.—Although the size of the inspection crews varies widely to meet different conditions, the average number of inspectors for plants of different sizes is variable. By careful estimating on all the plants it was found that on an average one man could handle the inspection work in a plant having 300 hp. in motors; two men, 600 hp.; three

(*Continued on page* 36)

Comments on Maintenance Work by Readers of Industrial Engineer

Readers of INDUSTRIAL ENGINEER in large works of a wide range of industries, where maintenance of equipment and power service takes on a variety of aspects, were asked the following questions. Their replies are tabulated below under headings corresponding to these questions:

Question No. 1. From your own experience what equipment is most often neglected or abused by an operating organization?

Question No. 2. In what departments of a plant or on what equipment can inspectors and maintenance men show the greatest saving?

Question No. 3. (a) Is the largest amount of maintenance work in your plant on mechanical or electrical equipment? (b) For industrial plants in general how does the general maintenance on mechanical equipment compare with that on electrical equipment?

Question No. 4. Check the following subjects that require the largest amount of the maintenance man's time as a general rule: Motors; control equipment; elevators; cranes; conveyors; lighting; factory call systems; mention any others and indicate order of importance.

Question No. 5. If you were required to check up the saving which can be shown by adequate inspection, general maintenance and overhauling of plant equipment, both mechanical and electrical, which of the following items would you consider the most important?

(a) Saving through prevention of costly breakdowns.

(b) Saving of spoiled material through fewer interruptions of processes.

(c) Saving shown by increased plant production through keeping work constantly moving and in process on machines with shutdowns at a minimum.

(d) Saving in life of equipment and fewer failures through inspections.

Reply No.	Question No. 1	Question No. 2	Question No. 3	Question No. 4	Question No. 5
1	Rubber Mills	Rubber mills and calenders	Mechanical	Motors	Item (d)
2	Power plant by failure to make necessary additions	Departments continuously in operation	(a) Mechanical (b) Mechanical about 25% greater than electrical	Elevators, cranes, conveyors and lighting	Item (d) first, item (a) second
3	That most easily abused	D. C. motors	It depends upon equipment used	Elevators and cranes	Item (b)
4	Manual motor control	Equipment where several machines operate in train	(a) Mechanical (b) Most on mechanical	Control and lighting	Item (d)
5	Lighting most neglected	Motor inspection 50% Safety inspection 50%	(a) and (b) about 50-50	Motors 25%; control 20%; elevators 15%; lighting 20%; factory call systems 5%; fire alarm systems 5% and general 10%	Item (a) first; (d) second; (c) third; (b) fourth
6		Motors, bearings, oiling and cleaning	Mechanical	Motors, control, elevators and lighting	Item (c) first; item (d) second
7	Electrical	Electrical and mechanical	(a) and (b) about 50-50	Motors, control, cranes, conveyors	Items (d) and (a)
8	Motors and lights	Electrical		Motors, lighting, factory call systems	Item (a) first; others important
9	Power and lighting equipment	In repairs to prevent a shutdown	Mechanical and electrical about 50-50	Same as answer to Question No. 1	Items (a) and (c)
10	Saw mills in lumber plants	Planing mill and shipping departments	Mechanical ⅔; electrical ⅓	Control and cranes	Item (c)
11	Electrical	Electrical—when one unit shuts down 15 to 20 men are idle	(a) and (b) about 50-50	Keeping dirt out of motors; checking oiling; repairing compensators	Item (d) first; (c) second
12	Motors and bearings	Controllers, brushes and commutators	(a) Mechanical; (b) neglect of mechanical repairs may be cause of electrical troubles	Motors when abused and neglected, control, cranes	(d) makes (a) possible and (b) and (c) are taken care of by observance of (a) and (d)
13	Motors are most abused in lumber mills	Mechanical department	(a) Mechanical; (b) mechanical costs are highest	Motors	Item (c)
14	Mechanical drives	By changing to electric drives	(a) Mechanical; (b) about 50-50	Conveyor chains, motors, bearings, belts, compensators	Items (d) and (a)
15	Power plant	Prime movers	(a) Mechanical; (b) 50% more than electrical	Control	Items (a) and (c)
16	Mechanical equipment	Preparing or wood department in paper mill	(a) Mechanical; (b) 5 to 10 times more than electrical	Control, conveyors, belting and pumps	Item (a) first; (c) second; (d) third
17	Motors and control	Motors	(a) Mechanical	Motors, control, lighting, factory call system	Item (c)
18	Electrical equipment	Electrical neglect may be more far reaching than mechanical neglect	(a) Mechanical; (b) electrical not as expensive	Motors, control and lighting	Item (c) first; (a) second; (d) third; (b) fourth
19	Electrical equipment	Motors, shafting and belts		Motors, control, lighting	Item (d)
20	Motors from overloads	Motors and control	(a) Mechanical	Motors and control	Item (d) first; (a) second

Continuation of Comments on Maintenance Work on Page 32

Reply No.	Question No. 1	Question No. 2	Question No. 3	Question No. 4	Question No. 5
21	Electrical equipment	Cranes, motors and control	(a) Mechanical; (b) 30 to 40% more than electrical	Motors, control, cranes, lighting	Item (c)
22	Conveyors and bucket carriers in cement mills	Material handling equipment	50% of repairs chargeable to elevation and conveying		
23	Electrical equipment	Motors and starters	(a) Mechanical; (b) mechanical 75%; electrical 25%	Control, starters, cranes, conveyors, elevators	Item (d) first; (a) second
24	Electrical equipment both neglected and abused	Key motors such as elevators and conveyors carrying materials from or to departments	(a) Mechanical; (b) higher on electrical in proportion to machinery used	Conveyors, grinding mills, elevators, motors, control, lighting	Item (c) first; (a), (b), and (d) important to get the (c) result
25	Production machinery	Machining departments	(a) Mechanical; (b) greater care is given mechanical	Replacing belts, motors, cranes, conveyors, lighting	Item (d)
26	Motor starters	Electrical and mechanical equipment	(a) Mechanical; (b) about two to one	Control, lighting	Item (c)
27	Motors	Power plant	(a) Mechanical	Motors, control, elevators	Item (c) first; (b) second; (a) third; (d) fourth
28	Mechanical equipment		(a) Electrical	Motors, control, elevators	Items (d) and (a)
29	Production machinery	Electrical control	(a) Mechanical; (b) mechanical two to three times more	Control on cranes	Item (d) first; (c) second
30	Electrical equipment	Steam plant	(a) Mechanical; (b) mechanical two to one	Lighting, motors	Item (d) makes savings in (a), (b) and (c) possible
31	Electrical equipment	Electrical and mechanical	(a) Mechanical; (b) three electricians against 26 mechanics	Motors	Item (c)
32	All pumps	In handling belts	(a) Mechanical; (b) electrical 75% of mechanical cost	All machinery breakdowns and belt repairs	
33	Machine tools and drives	Mechanical	(a) Mechanical	Control, elevators, motors, conveyors, factory call and fire alarm systems	Item (a); also importance of carrying repair parts
34	Electrical and mechanical both neglected and abused	Machinery, shafting and pulleys	(a) Mechanical	Inspect all electrical equipment	
35	Lighting shamefully neglected	Control equipment on drives frequently started	(a) Mechanical department has 35 men; (b) electrical department has 5 men on maintenance	Control, elevators and lighting	Item (a)
36	Maintenance of protective devices	Inspection of electrical equipment	(a) and (b) about 50-50	Motors and lighting	Item (d) makes savings of (a), (b) and (c) possible
37	Electrical	Lubrication of bearings	(a) Mechanical 70%; (b) electrical 30%	Motors, elevators, conveyors	Item (d) and (c)
38	Automatic control	D. C. Motors	(a) Mechanical; (b) electrical equipment kept in better condition	Motors	Item (d)
39	Mechanical neglected — electrical abused	Mechanical	(a) and (b) about 50-50	Motors 50%; control 20%; elevators 5%; conveyors 10%; lighting 14%; factory call ½%; fire alarm ½%	Items (a) and (c)
40	Equipment used by several operators	Group drives	Mechanical	Motors in summer, motors and lighting in winter	Items (c), (a) and (d)

While the answers to the questions asked vary according to the character of mechanical and electrical equipment operated, they indicate in a very definite way the kind of thinking that is given to works maintenance from all standpoints. Answers to questions Nos. 1, 2, 3 and 4 are for the most part self explanatory. An interesting variation of opinion is shown, however, in the answers to question No. 5. Of the 40 replies, seventeen give first place to division (d) of question No. 5; ten to division (c); eight to division (a) and one to division (b). Also eleven replies mention combinations of divisions (a) and (d). The significance of these eleven replies is that they represent works where inspection and general maintenance work is well organized. The replies that give first place to division (c) are those where production is carried on in a progressive chain or on groups of equipment.

The following comments supplement the replies in the table and bring out some additional details of maintenance work.

James Foster, Electrical Superintendent, L. D. Leach & Company, Cairo, Ill., states that his company is engaged in the manufacture of oak flooring and lumber of interior finish dimensions. The electrical equipment consists of 60 motors with a connected horsepower of 1020 and a 150-kw., 220-volt, 60-cycle generator. The generator load is carried at unity power factor by driving a large fan on a dust collecting system with a 150-hp. synchronous motor. The average daily load of the plant is 3800 kw. hrs. and energy is purchased with an arrangement provided so that all feeders can use either source of power by manipulating double-throw switches.

Mr. Foster says that his experience has indicated that the electrical end of factory equipment is more abused than any other, owing to the use of transient and common labor in operating machines. He believes that the maintenance man can show the greatest saving in the electrical department since delays in production caused by shutting down to change bearings or compensator parts is very expensive. When one unit is shut down from 15 to 20 men are idle. The largest amount of the maintenance man's time is taken in keeping dust and dirt from the motors, checking the oiling system and repairing compensators.

In reference to the question on saving shown by adequate inspection, maintenance and overhauling of plant equipment, Mr. Foster states that since production is essential in the plant, adequate inspection results in increased and continuous production. Constant vigilant inspection is maintained on all apparatus, consequently little defects are caught before they can develop into a cause for breakdown. All reports are investigated and repairs made on the night following the daily report. An adequate supply of bearings, coils and compensator parts is maintained at all times. The maintenance work is taken care of by the electrical superintendent, one electrician and one inspector.

F. G. Bonn, Chief Electrician, Hammond Cedar Company, Hammond, B. C., Canada, makes the following comments in addition to answering the maintenance questions referred to in the accompanying table:

"When I came to this lumber plant everything was steam driven. Now nine-tenths of the mill is motor-driven; in fact, everything but the head saw and log haul. Where we have gained is in room, as the many shafts and counter-shafts with belts and gears took up much space below the floor. The first installment cost has been quite high. It figured about $18 per horsepower, but considering the enormous saving on belts, oil and leather, we can say that the change soon paid for itself. Furthermore, we can run part of the plant without interfering with the other now.

"*Question No. 3*—The maintenance on mechanical equipment is still higher than the electrical equipment, but I believe it will soon run 50-50. I include in electrical equipment lights and alarms. The mechanical maintenance man has to spend a good deal of his time on conveyor-chain repair, but this has been considerably improved by putting all conveyor chains on one standard and by making the links in our own shop. We are using a chain with 10-in. pitch and 10-in. width throughout. About 50 per cent of the time of maintenance men is spent on motor troubles which are 70 per cent caused by bearing trouble, often through too tight belts. That is why we put in as many direct drives through flexible couplings as possible. About 40 per cent of the time is spent on compensators, as the points are often badly burned by incorrect starting. About 10 per cent is spent on lights and alarm equipment.

"I believe we save most through preventions of breakdowns and shutdowns by our regular inspections. Some parts, as carriages and some conveyor chains, are daily inspected; other parts weekly and some monthly. This also applies to the electrical equipment. For the electrical department I keep a record of all repair work with the time. From these records I have been able to tell how often I look at certain compensators. Motors with belt drives are inspected now every first week in the month. The belts are run off and the play in the bearings inspected.

"I might state further that the saw mill requires about 60 per cent, the planing mill 20 per cent, the shingle mill 15 per cent and the lath mill about 5 per cent of the electrical maintenance man's time. Mechanically, the saw mill requires 50 per cent, the shingle mill 30 per cent, the planing mill 10 per cent and the lath mill 10 per cent of the maintenance man's time."

H. L. Hayes, Chief Electrician, St. Croix Paper Company, Woodland, Maine, comments as follows in addition to answering the questions mentioned in the accompanying table.

"*Question No. 1*—Based on the resultant damage from a small amount of neglect, I think that electrical equipment is the most abused. For instance, a tight belt on a line shafting may burn out a bearing and the damage end there, but a tight belt in burning out a motor bearing may also burn out the complete motor winding.

"*Question No. 2*—In our plant the paper machines being direct producers should and do receive the greatest amount of maintenance. Lack of it would produce the greatest loss. Next comes the boiler room because neglect there means a direct loss in coal. Electrical equipment comes third because neglect may be more far reaching than ordinary mechanical neglect.

"*Question No. 3*—In our plant I think that inspection of the electrical equipment is more systematic, but it is not as expensive, and the maintenance is not as great as on the mechanical equipment. In general, taking power developed, the engines and miscellaneous mechanical equipment require and have a great deal more maintenance expense and attention than the electrical equipment.

"*Question No. 4*—In our plant the subjects receive the most attention in order listed: Motors—including cleaning; control equipment; lighting. The other subjects are of minor importance because we have a very small amount installed.

"In regard to question No. 5, I believe their importance is in the order listed below: No. c, first; No. a, second; No. d, third; No. b, fourth.

H. M. Cullen, Chief Engineer, International Paper Company, Turners Falls, Mass., states that no equipment is neglected more in the average plant than electrical apparatus. "In many installations the master mechanic or engineer in charge may have little knowledge of electrical operation and feel afraid to undertake repairs on motors and starters. The fact that many motors are running under these conditions today speaks well for the makers. Few maintenance men appreciate the necessity of keeping motors clean and consequently motors are allowed to run until the insulation breaks down.

"Motors should be systematically inspected, cleaned and the bearings kept filled with clean oil. The air gap should be tested at least once each month and the belts should be gone over each week. Care should be taken that oil does not find its way into the windings and lower parts of the stator in a.c. motors. Under such conditions it is impossible to blow out the dirt which accumulates there and the result is a breakdown of the insulation on the coils.

"Starting boxes and compensators should be inspected, since poor contact on one phase may cause the motor to run hot. The writer keeps a card index on file for each motor that shows all work done with the corresponding date. Each motor has its number painted in white figures on the frame and on the starting box. The compensator also carries a red arrow showing the direction of rotation.

"Once each week the rotors are taken out of motors and the windings thoroughly cleaned and given a coat of insulating varnish. Oil and dirt can cause more trouble with motors than all other things put together and a regular and thorough system of inspection will go a long way toward preventing breakdown."

K. L. Rose, Assistant Chief Electrician, Chevrolet Motor Company, Flint, Michigan, says: "From my point of view, electric motors receive about as much abuse as any equipment in industrial works. Where motors are carrying heavy overloads night and day there is an indication that something is radically wrong when they happen to stop. Yet the operators will often try to start them. If they will not start, the lever is frequently pulled back to the running side and left there. This is a kind of carelessness that must always be contended with. If maintenance men would show operators a few things about taking care of their machines, much could be accomplished in reducing troubles. Usually the machine operators know nothing at all about electrical equipment. It would be difficult for me to say whether the saving by inspection and general overhauling will be greater by preventing costly breakdowns or failures, but I believe that some knowledge of the equipment and thorough inspection will prevent both."

N. W. Coffey, Mechanical Engineer, Southwestern Cement Company, El Paso, Texas, states that in a cement

mill the screw conveyors and pivot bucket carriers are neglected and abused more than any other equipment due to the fact that screw conveyors are always cased in to prevent the escape of dust. Pivot bucket conveyors cause less trouble, due to the fact they are open and in sight for inspection at any time. "In my estimation in this particular plant I would say the kilns are the most important part of the plant. The heat from the kilns is utilized in waste-heat boilers to furnish steam for the generation of electric power for the production of cement.

"It occurs to me, from an operating standpoint, that successful conveying and elevating devices are of most concern in the manufacturing of cement. It is true that we would have no need for the agents were it not for the quarry, the railroad transportation facilities, the crushers, dryer, raw grind, kilns, etc., however, it is precious little time we ever lose in our operations because of these machines, probably due to our efficient operators, or to the machines being made fool proof. In any event, we have run better than 95 per cent of a possible 100 per cent this season so far as department machines are concerned.

"I would not convey the idea that we have lost a great amount of time because of the elevation and conveying devices that we have in service for this would not be true. However, inasmuch as the cost of repairs for the elevation and conveying machines together with the labor cost necessary to keep the devices in repair is of such moment, I do not feel that there is any argument but that the handling of the material is of most concern.

"The exact figures in this instance are not available; however, from observation, I would say that of the repairs we have made this year, 50 per cent of the labor and material could justly be charged to elevation and conveying."

J. H. Gallant, Chief Electrician, Canada Cement Company, Belleville, Ontario, Canada, states: "From experience I believe that the electrical equipment in a manufacturing plant is most often neglected and abused, not wilfully as a rule, but through ignorance and misapprehension of what it really can or is intended to do.

"Question No. 1—In the electrical department especially the neglect and abuse is in the case of key motors, such as motors on elevators, conveyors, etc., which carry material in process to or from a department; also on motors with any system of remote control, push buttons, switches, etc.

"Question No. 2—In the mechanical department special attention to lineshafts for alignment and to bearings will always show results in increased production due to fewer and shorter interruptions.

"Question No. 3—In our plant the mechanical end requires more maintenance work than the electrical end, especially since we have changed the majority of our motors to ball bearings. I am satisfied that by changing all our motors to ball bearings that we will cut down our electrical maintenance work by over 60 per cent. For industrial plants in general, maintenance costs are higher on electrical than on mechanical equipment in proportion to the machinery employed.

"Question No. 4—In our plant the maintenance man's time is taken up mostly by the following in the order given: Conveyors, pebbling, relining and repairing grinding mills, elevators, motors, control equipment and lighting.

"Question No. 5—In my estimation the most important item in which a saving can be effected through proper inspection, maintenance and overhauling is No. (c), namely, "by increased production through keeping material or work in process constantly moving, with minimum shutdowns." The other three items seem to be subsidiary to this third one of "keep going." Regarding the first or saving through the prevention of costly breakdowns: If breakdowns are avoided the material will keep going and it is very seldom indeed that the costs of labor and materials for repairs on any breakdown come to anything near the loss due to the machinery being idle. The second, "the saving of spoiled materials through fewer interruptions of processes," naturally depends on this first mentioned third item. As for the fourth item, "the saving in the life of equipment and fewer failures through inspection," the only and ultimate end of proper inspection and maintaining machinery in good order, is this ideal of all industrial executives to "keep going."

"All inspection, however, will be more or less useless unless the inspectors' reports be acted on immediately after they are received and thus by timely repairs save costly breakdowns, costly especially through the machinery being idle while repairs are made, which, if attended to in time, could have been done in a fraction of the ultimate time required."

Paul Justus, Superintendent Electrical Department, Chandler Motor Car Company, Cleveland, Ohio, points out that machine tools are often neglected or abused in a large works owing to the fact that they are frequently purchased too small for the work they are to perform or are crowded beyond their cutting, drilling or planing capacity. Owing to the fact that a machine tool usually requires considerable more time to overhaul than a motor, the production department is slow in consenting to have it taken out of service. "Keep it going" is the usual watchword.

In reference to the maintenance of fire alarm systems, Mr. Justus states that owing to the extreme importance that this system shall function properly at the time when most needed, greater care is used in making the installation and hence it requires less upkeep than some other factory electrical systems. He considers the saving effected through prevention of breakdowns the most important item in general inspection, maintenance and overhauling of plant equipment combined with the carrying of sufficient repair parts to be able to quickly repair unforeseen breakdowns and natural wear and tear.

Otto L. Schendel, Electrician, S. Karpen & Brothers, Michigan City, Indiana, states that from his fourteen years of experience in the maintenance of mechanical and electrical equipment, the upkeep and repairs on machinery, shafting and pulleys is far greater than similar work on electrical equipment. The Michigan City plant of the company was formerly operated by steam, using a 250-hp. Corliss engine to run one half of the factory while the other half was operated by 25 motors on purchased power. Since January, 1922, an Allis-Chalmers steam turbine has been added and a large number of Crocker-Wheeler and General Electric motors. Most of the machinery is now operated by individual motor drives. At present 120 motors are in service, ranging in size from 1 to 50 hp., 440-volt, 60 cycles. A large turbine will be installed in 1923 to take care of service in the plant which is now operated on purchased power.

"Motors are given an inspection once a day. Every Saturday they are blown out, cleaned of oil and are tested for load, rotor clearance and bearing wear, which are the main points in keeping the equipment in good operating condition. Two maintenance men and their helpers take care of this work and besides wire hundreds of lamps which the firm manufactures.

Joseph F. Adams, Chief Electrician, International Harvester Company, Akron, Ohio, in answer to the question on equipment neglected or abused by an operating organization, calls attention to factory lighting. He states that not only is inadequate lighting provided as a rule but that which is provided is frequently forgotten and soon becomes very poor and inefficient.

He also refers to frequent abuse of control equipment, especially that used with motors that are started many times during the day where a group drive is provided.

A. E. Arnold, Electrical Engineer, Oakland Motor Car Company, Pontiac, Michigan, states: "I find the greatest neglect occurs in the maintenance of protective devices. Either the operating electrician fails to attach much importance to them or else he looks on them as a necessary evil. I believe, however, the former is the case. It seems that the conception of a protective device by the average electrician is that it requires no attention because it has been designed to operate automatically and will do so regardless of any other condition. I have seen relays in which the set screws have be-

come loose and allowed the setting of the iron plunger to change considerably; also the small copper contacts which are usually incorporated into the design of a relay of the solenoid type have been allowed to oxidize to such an extent that the relay would be absolutely useless, due to the high resistance in the operating coil circuit.

With reference to fuses I find the same laxity exists. Fuse clips are not given the attention required. Also an overload may have occurred at some period in which the fuse failed to blow and consequently the clips have become heated and annealed, thus permitting the clips to lose their effective pressure on the ferrule of the fuse which would eventually injure the equipment it was protecting.

"In answer to the question: 'In what departments of the plant or on what equipment can inspectors and maintenance men show the greatest saving?' I infer that you mean the ultimate saving possible. In a plant that is entirely operated by electric motors, such as ours, I would say that the motor is the vital factor in determining the saving to be made. I believe that personal instruction on maintenance and inspection by the chief, followed up with a printed form containing a systematic routine method of inspection covering the motor in all the essential details and used as a general schedule for every-day use (the schedule of inspection to be continuous in operation) will show the greatest saving.

"In answer to Question 3, on a comparison of general maintenance of electrical equipment with that on mechanical equipment, in general I would say that there is about as much work in one division as there is in the other, this being based on the number of men required for each department during a production period. Motors and lighting require the largest amount of the maintenance man's time as a general rule.

"In reference to the saving which can be shown by adequate inspection, general maintenance and overhauling of plant equipment, both electrical and mechanical, I believe that saving in life of equipment and fewer failures through inspections makes possible the other three savings which are mentioned. As the continuous operation of a plant depends on the readiness to work of all the factors that go into producing the final product, it is easily seen that if all these factors are inspected and watched carefully there would be no costly breakdowns or spoiled material or the necessity of shutdowns occurring, to reduce the final output of the plant."

(*Continued from page* 31)

men, 1100 hp.; four men, 2000 hp., and five men, 6000 hp. As already stated, operating conditions will vary these numbers considerably.

Frequency of Inspections and Overhauling.—Once a week is the favorite time for making inspections. Thirty companies (out of sixty-two reporting) conduct weekly inspections on motors; seventeen companies daily, and six monthly. Forty-seven companies reported that they inspect control equipment. Twenty-three referred particularly to cranes and twenty-four to material-handling equipment. The inspection periods for all of these follow the same order as for other equipment; namely, daily, weekly and monthly.

namely, daily, weekly and monthly.

Thorough overhauling is done as it becomes necessary in 34 plants out of fifty-four reporting. Twenty-eight plants overhaul at regular intervals. The interval between overhauls is one year for eighteen plants and six months for four of them. Most of the plants have no specified time for overhauling and in many cases overhauling is being done continually, passing from one machine to the next, in rotation. In thirteen cases where overhauling is done at regular seasons, seven of the dates fall in December, January and February.

Amount of Maintenance Stock.—The average amount of wire kept in stock by fifty-one companies reporting is about 3,000 ft., mostly of No. 14 and No. 12 B. & S. gage. Eight of the plants keep one set of brushes per motor, and four plants keep one set only. Among twenty-one other plants the average number of brushes in stock is 35. About 88 lb. of babbitt is the average of thirty-seven plants, and 42 pounds of solder is the average in forty-two plants.

Eighteen of the plants reported that coil and slot insulation is kept on hand. The average amount is 50 lb. Plant No. 26 in the table keeps 50 lb. each of 1/16-in. leatheroid, 1/32-in. leatheroid and mica plate, and also 25 lb. of grade B oiled linen. Plant No. 44 keeps cotton tape, oiled linen, asbestos and slot paper. This, in general, is the kind of insulation carried by all the plants which do repair work. Plant No. 44 also carries one-third to one-half a set of coils for a few of the most important motors. Plant No. 54 keeps on hand $500 worth of insulation.

Lamp stocks are kept on the average, at about 50 per cent of the number of lamps installed. In all the plants there are about 116,000 lamps totaling 16,000,000 watts. The 60-watt size leads in number (29,055) and in wattage (1,743 kw.). In wattage the 200-watt size is next (1,500 kw.) and the 75-watt size is third (1,462 kw.). In numbers the 75-watt is second (19,675) and the 40-watt size is third (15,240).

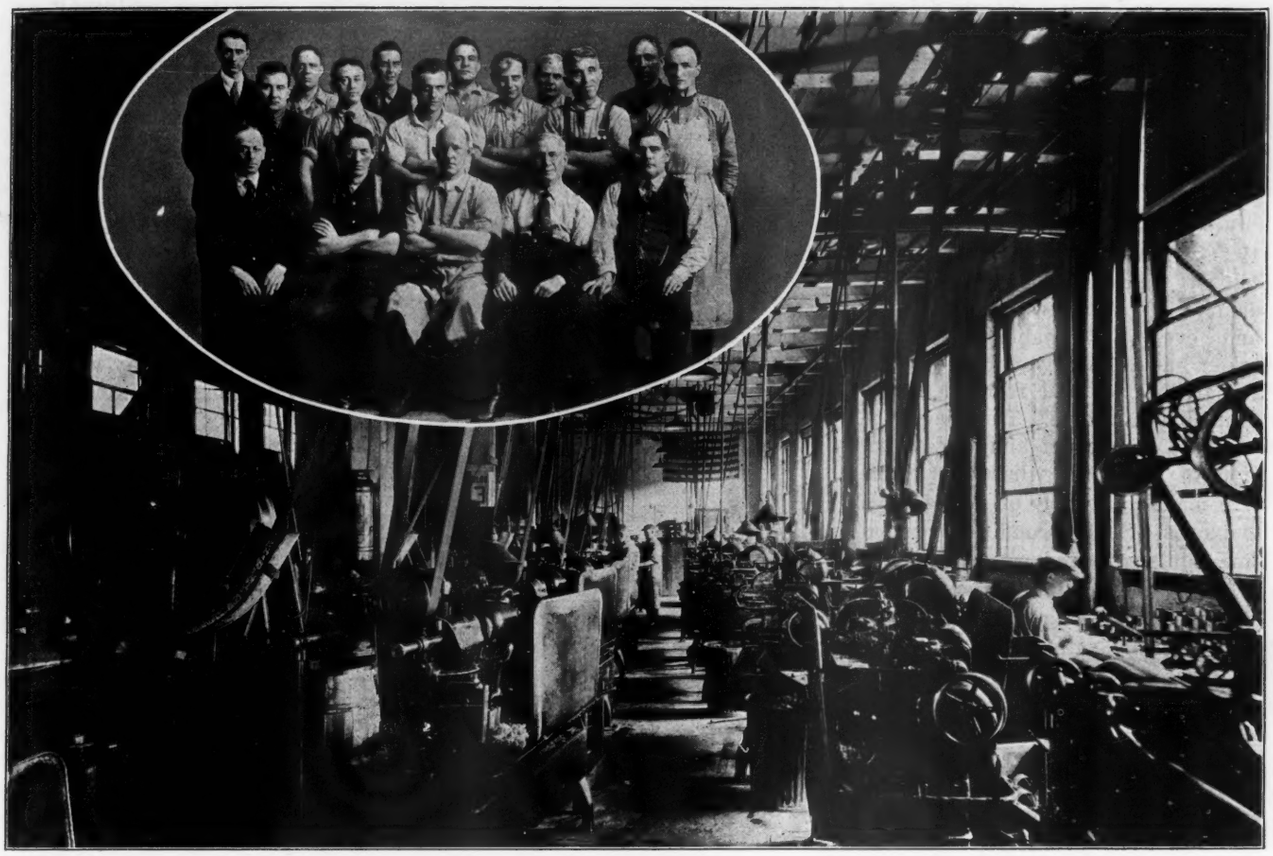
For every hundred lamps installed there are 137 replacements per year. One paper mill, No. 50 in the table, has 360 per cent of lamp replacements per year. A fertilizer plant (No. 21) has 300 per cent; a plant for leather boots (No. 43), 250 per cent; a valve plant (No. 33), 220 per cent, and a cement plant (No. 7), 200 per cent.

It has been noted that the plants making electrical equipment did not list much maintenance stock. These plants have material on hand for manufacturing purposes and do not have a separate storeroom for the maintenance department.

Responsibility for Maintenance, Production and Non-Interruption.—An interesting part of the table is found in the last two columns referring to the responsibility for maintenance, production and non-interruption of service. In thirty cases out of sixty reporting, the same man is in charge of all three divisions of plant service. In only four cases the man who has charge of maintenance and non-interruption of service, is not responsible for production.

The men in charge of maintenance in the different plants have twenty-two different titles and there are six who have no title at all. Of all these men, eight are superintendents; nine, master mechanics; four, electricians; three, engineers; six, no title.

There are 23 plants out of 53 reporting on productions where the man in charge of maintenance does not have charge of non-interruption and production. The men who have charge of this work has collectively eight titles. There are seven superintendents in this group and one each of seven other titles and one without a title. The titles of superintendent, master mechanic and works manager occur both in this group and in the group of men who have more direct charge of maintenance.



This group of men has a record of 29 months without a lost-time accident among these surroundings where one would hardly expect such a record.

Underlying Influences Which Contributed Toward

29 Months Without a Lost-Time Accident

In One Department and a Similar 14-Months' Record for the Entire Works

By WILBUR WOODAMS,
Safety Engineer and Employment Manager, Hawk-Eye Works, Eastman Kodak Company, Rochester, N. Y.

CAN A factory with the usual complement of hazards achieve a record of one whole year without a lost-time accident? It can, and here follows the account of how it was accomplished.

In discussing this achievement for the INDUSTRIAL ENGINEER it would be most fortunate if a complete outlay of mechanical safeguards could be pictured and offered as the cause of a record which is at least unusual. The description of what has occurred would then be comparatively simple, and a duplication of the record easily brought about if the installation of mechanical prevention would duplicate the trick. It is true that little which seemed of value in the line of guards and mechanical aids to accident prevention was omitted, and the effort expended in this line did much to achieve the results attained. However, it is in the individual within the plant, and his use of the tools with which he works, that the true reason for accidents or their absence must be found. To the attitude of the whole force—the *collective individual*—call it plant spirit, plant pride or whatnot—the record of the Hawk-Eye Works of the Eastman Kodak Company must be credited.

This division is a small plant manufacturing a large variety of products, all of which fall in the general class of photographic accessories. The machinery consists of a wide variety of metal, woodworking and optical machinery, with the addition of a number of special machines. During the fourteen no-accident months, which extended from June, 1921, to August, 1922, the average number of employes on the pay roll was slightly in excess of four hundred. It would, perhaps, not be unduly pessimistic to suppose that even so moderate a number of people, spending 8¾ hours of each working day in any active capacity, in a five-story plant, would come to some mishap, even without the additional hazard of machinery. Yet a force consisting of approximately two-thirds men and one-third women avoided even the tumbles on the stairs, the infections, the slipping and the hazards of falling materials.

It is not to be expected that

scratches and near accidents did not occur. In making this record a lost-time accident was considered as one which caused loss of time in a day other than the day on which it occurred. This is the same as a "reportable" accident as required by the New York Industrial Commission.

For several years ending with 1920, we had been paying an annual toll of approximately twenty accidents. The work was well guarded and every reasonable precaution taken but seemingly without effect. Apparently we had reached an irreducible minimum. Then came the business depression and the reduction to the point where the force was made up largely of long-service employes. Such a condition reacted immediately to reduce accidents to a very low point. Experienced workmen and long term employes are generally safe. With the accident rate at this low point in the spring of 1921 we began definitely to study the possibility of lengthening the interval between accidents with no goal set beyond the immediate present. The only object was to pass each successive day with a clean record. Interest increased as time went on until the effort to continue the record became a part of the consciousness of the whole force. Success succeeded. The spirit, the zest of the game, became its own motive power. Then gradually there grew a pride in the achievement in which each individual had his share.

The experience of one department at Hawk-Eye, in which is crowded a miscellaneous lot of manufacturing, offers a good example of the value and growth of this pride. The work in this department requires the use of a variety of metal working machinery, including some 20 presses used in blanking and forming jobs, draw presses, mills and drills, automatic and hand screw machines, square shears and lathes besides a large number of bench forming operations and soldering jobs. The work of the department was done on the bonus system with speed and production at a premium. Accidents were not unexpected here.

The change in the attitude of the department came gradually. The first no-accident month occasioned little interest; it had happened before frequently. The second caused some curiosity. After three months without an accident these men began to realize that they were making a splendid record. They began to take a lively interest in the addition of each successive day to their record. Men who apparently had never been conscious of accident prevention efforts began to say, "another day without an accident," or "another week and still going." The end of each month added to the record became the occasion for celebration. Their success was to them a real accomplishment; it was *theirs*, and *they* were making it.

The work of the department has always been well guarded. There was no change in methods. The difference was due solely to the changed attitude and the pride of accomplishment on the part of the operators. Needless to say we have first-class foremanship in that department with the foreman at all times the real leader of his men. It is twenty-nine months since the last lost-time injury to one of his employes and the record is still growing. There is no safeguard like the pride of accomplishment. We do not belittle mechanical safeguards, but it seems evident that they are but a part of real accident prevention.

MR. WOODAMS makes the following significant statement: "Any safety campaign will stand or fall according to the measure of co-operation secured from the Maintenance and Construction Department..... Incidentally there is no single group which can so successfully combat the hazards which continually occur when least expected throughout the plant. Watchfulness and real interest on their part has an immeasurable value in any safety campaign while carelessness is certain to end in disaster, either for themselves or for some fellow workman. When they are on the job safety begins with the machine. When these men become safety workers much of the routine of accident prevention is eliminated."

The Maintenance Department's Place in a Safety Campaign

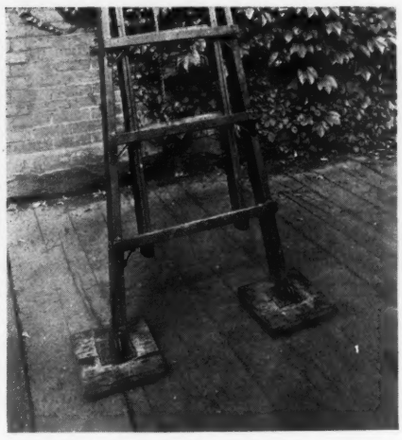
Any safety campaign will stand or fall according to the measure of co-operation secured from the *Maintenance and Construction Department.* Scattered about the plant, often without direct supervision, moving heavy objects, salvaging, oiling and performing all the kindred occupations which go to make up the daily tasks of maintenance men, they are quite generally unguarded except by their own care. Their work is a danger point in any safety cam-

Maintenance men do much of their work alone with little direct supervision.
For this reason they must be convinced of the necessity of thinking safety. This man is removing rungs from the horse so that it will fit over the lathe. Will he remember when he comes down?

paign. Incidentally there is no single group which can so successfully combat the hazards which continually occur when least expected throughout the plant. Watchfulness and real interest on their part has an immeasurable value in any safety campaign. Carelessness on the part of maintenance men is certain to end in disaster, either for themselves or for some fellow workman. When they are on the job, safety begins with the machine. When these men become safety workers, much of the routine of accident prevention is eliminated.

We did not realize the importance or value of the *Maintenance and Construction Department* before our no-accident year as thoroughly as we do now. During that period we began to check the maintenance men more closely and to learn the possibilities for service that exist in their work. The attention which was focused on them, and the success which met their efforts aroused in them a loyalty to the cause which had previously been a useful force lying dormant. Here again, however, the question of foremanship was paramount. The foreman not only grasped the idea himself but got it across to his men successfully.

For some time we had conducted our safety work on a basis of departmental competition. We found that in discarding this method we were able to replace it with a combined effort to make the whole plant safe. It was at this point that the work of the *Maintenance Department* was invaluable. The idea was given to them through their foreman and through individual talks with the men of the department. A "progress report," reproduced on page 40, submitted monthly by the foreman which detailed the accident prevention work done by the department, was, and still is, a source of inspiration. It does not hinder in the least to let them know that their work in this regard is watched.



This extension ladder will not slip.

Coco-matting is fastened on the bottom of these boards hinged to the foot of the ladder. It can be placed in practically any position. This accident-prevention idea evolved from a suggestion made by one of the men. The principal factor in safety work is to get the men to think "Safety." They will then be careful and make suggestions which may be of much value in furthering accident-prevention work.

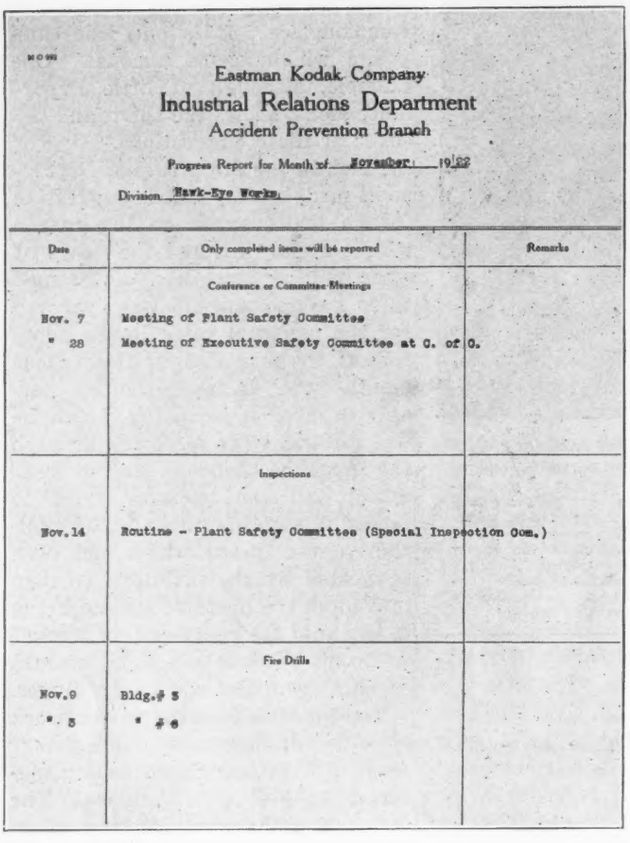
It would be extremely difficult to select any single prominent incident in which our *Maintenance Department* has aided in reducing accidents, as each incident in itself is commonplace. It is only the composite which seems unusual. One example, although of little importance alone, shows the spirit and the effect of these suggestions. One of the men in the *Maintenance Department* made a simple little suggestion for an improvement on the guards which already covered the gears of some milling machines. It seemed to be a refinement but was approved for the potential value in the adoption of the man's suggestion. Some months later an inexperienced operator dropped a small lug which he was milling. The piece fell through the machine, landed on the gear guard and the operator tried to rescue it with his finger. The addition to the guard which had been suggested by the maintenance man prevented the operator's hand being drawn into the gears and let him off with only the loss of a small amount of skin from the end of his finger.

The greatest hazards in the work of our *Maintenance Department* seem to have been from falling materials and slipping ladders. The last named hazard has been effectively overcome by the use of coco matting feet on the ladders, a suggestion made by an employe of the Kodak Park Works. They have been in use for something over a year and so far have functioned perfectly. The hazards of falling materials, faulty tools and equipment, as well as the many other dangers to which maintenance men are exposed can only be eliminated by care and foresight on the part of the men themselves. There is no other preventive. The best, and therefore most difficult, factor of safety work is that which teaches and inspires care and foresight. First we tried to merit the co-operation of the men of this department, then to give them credit for the results of their efforts.

The attainment of this co-operative attitude on the part of the employes of any company depends directly upon its labor policy. Therefore, management must merit co-operation in the safety movement by its attitude toward *all* questions in-

He forgot that he had taken the rungs off.

In this case the maintenance man put himself in danger. Often, however, his carelessness endangers others, since by leaving heavy objects overhead or debris on the floor as a tripping hazard, or through neglect to replace guards. He is in an excellent position to see hazards and will suggest methods of removing them if he receives recognition and encouragement.

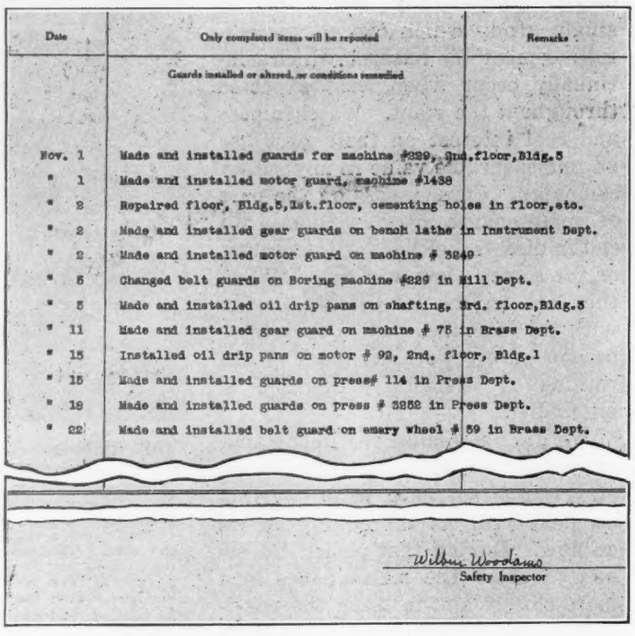


Eastman Kodak Company
Industrial Relations Department
Accident Prevention Branch

Progress Report for Month of November 1922

Division Hawk-Eye Works

Date	Only completed items will be reported	Remarks
	Conference or Committee Meetings	
Nov. 7	Meeting of Plant Safety Committee	
" 28	Meeting of Executive Safety Committee at C. of C.	
	Inspections	
Nov. 14	Routine - Plant Safety Committee (Special Inspection Com.)	
	Fire Drills	
Nov. 9	Bldg. # 3	
" 5	" # 6	



Date	Only completed items will be reported	Remarks
	Guards installed or altered, or conditions remedied	
Nov. 1	Made and installed guards for machine #329, 2nd. floor, Bldg. 3	
" 1	Made and installed motor guard, machine #1438	
" 2	Repaired floor, Bldg. 5, 1st. floor, cementing holes in floor, etc.	
" 2	Made and installed gear guards on bench lathe in Instrument Dept.	
" 2	Made and installed motor guard on machine # 3849	
" 5	Changed belt guards on Boring machine #229 in Mill Dept.	
" 5	Made and installed oil drip pans on shafting, 3rd. floor, Bldg. 3	
" 11	Made and installed gear guard on machine # 75 in Brass Dept.	
" 15	Installed oil drip pans on motor # 92, 2nd. floor, Bldg. 1	
" 15	Made and installed guards on press # 114 in Press Dept.	
" 19	Made and installed guards on press # 3252 in Press Dept.	
" 22	Made and installed belt guard on emery wheel # 59 in Brass Dept.	

Wilbur Woodams
Safety Inspector

"Progress Report" on which safety work completed during the month is reported.

It is encouraging to see what has been accomplished each month. This progress report also gives credit for work completed. It is made by the safety engineer to the general safety supervisor of the company. The reverse side of this report, shown above, carries the list of work done which the foreman of the Maintenance Departments sends in monthly. No printed form is used for his report; it is simply an enumeration of the items covered.

volving employe relations. It should not seem boastful in the light of the record made, to say that co-operation has been obtained at Hawk-Eye, at least in the field of accident prevention. Our safety organization begins with the management of the company.

How Safety Work Is Organized

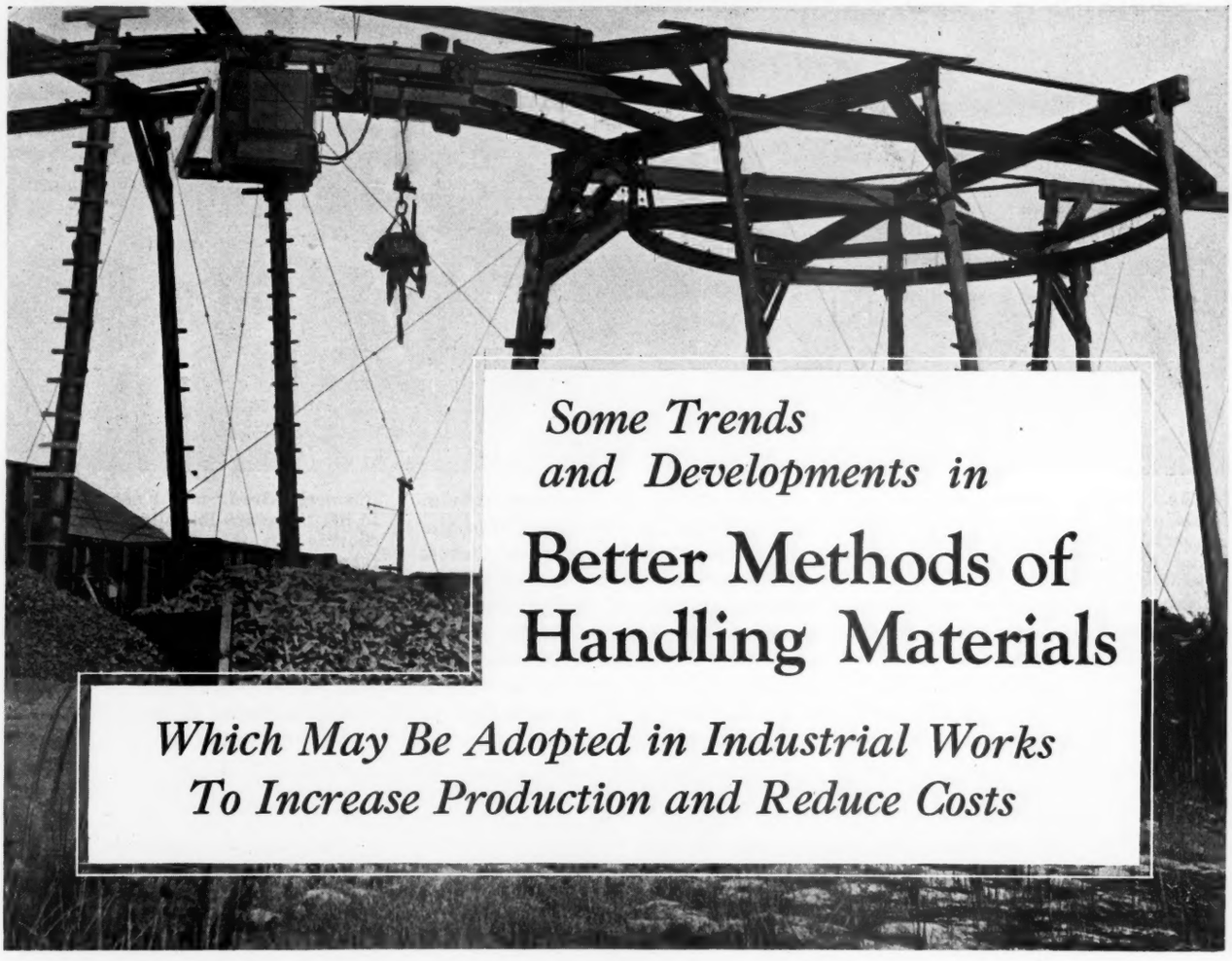
Within the plant we are organized simply with a safety committee representative of each department and headed by a chairman appointed by the management. The departmental representatives are appointed by the foremen as their selection in this way has been found to achieve greater co-operation within the department than the former method of appointment by the committee chairman. Departmental representatives are chosen semi-annually, and are rotated as far as possible in order to give the experience to as many people as possible. In addition to the regular representatives, a few others who have proved their interest and value to such an extent, are considered more or less permanent members of the committee.

Meetings are held monthly for the discussion of suggestions and progress made since the last meeting. The chairman appoints a sub-committee of three each month which makes a complete inspection of the plant and reports in writing at the next meeting. These are submitted to the superintendent for disposal. The work of the plant safety committee has been, throughout, an important factor in making the work of real interest to the employes rather than an effort imposed by the management.

The part played by propaganda in the success we have had is of course difficult to estimate. Persistence in this regard combined with an effort to put forth the best available undoubtedly contributed in good measure to the result. Any form of propaganda, be it bulletins, charts, signs, object lessons or whatnot defeats its own purpose if it is allowed to become stale and worn. It must be handled so that it attracts attention or it is valueless. We found that after a siege of safety propaganda a favorable reaction resulted from a temporary total eclipse of advertising effort. We omitted the sensational, the gruesome, and tried to maintain a serious tone. Education should be the foundation of all safety propaganda but it must be interesting and sincere to be effective.

Our plant dispensary, or hospital, as we call it, has been a contributor to our accident prevention work. The treatment the operator received in the hospital made it possible to send the man there with the slight cut for treatment without resentment. Our employes have been taught that it is not a sign of weakness to have even the smallest abrasion cared for by the nurse. The important fact is that they did come, and while there is no way of estimating the number of infections prevented in this way, it does not seem extravagant to say that we would not have had a no-accident year without such free access to and use of the hospital.

If there is any single lesson to be drawn from the results attained at the Hawk-Eye Works, it is that safety work in itself is but one unit in the whole picture. The best of accident prevention work cannot succeed by itself alone. It cannot achieve the results desired without that co-operation which comes only when merited in every phase of the contact between management and its men. Nor is it necessary that management surrender its prerogatives to secure co-operation. If the men are satisfied that they are led by competent men they will not desire to usurp their power.



Some Trends and Developments in

Better Methods of Handling Materials

Which May Be Adopted in Industrial Works To Increase Production and Reduce Costs

One man in an inclosed cab can operate this magnet or grab bucket in any kind of weather for handling pig iron, scrap, coke, or similar materials.

By FRANK E. GOODING
Associate Editor, Industrial Engineer

UNTIL RECENTLY, but little attention has been paid to careful analysis and standardization of the best methods of handling materials in industrial plants. Some attention had, of course, been given to improvements in certain operations and processes of the work, but these were not developed in such a way that they fit together. Too often the addition of a hoist, conveyor or an electric truck was considered a solution of the problem when it solved only part of it, yet big economies have resulted from such installations.

When it is considered that a large percentage of all industrial operations or processes are handling operations—picking up, laying down, or moving—the importance of the best methods of doing this work may be better realized. For example, a year or two ago the chief engineer of Deere & Company, Moline, Ill., showed by a careful analysis that it was necessary to handle—actually pick up and move—168 tons of material for each ton of finished castings produced from his foundry. A check in many other similar works would show that the pig, scrap, coke, limestone, cores and molding sand, patterns, flasks, debris, castings and miscellaneous other materials are handled many more times than were indicated in this check. These necessary handlings may be performed by hand, by mechanical or electrical equipment, or by combinations of hand and equipment.

The big savings lie in choosing the proper combinations and in making the best use of them. For example, wheelbarrows, hand loaded, may be satisfactory for moving pig iron in one plant while in another a combination of cranes, hoists, magnets and electric trucks or tractors are required. Where several men are employed most of their time on any handling operation, however, the economies in the use of equipment to do their work is worth investigating. Many material-handling installations have paid for themselves in less than a year and some within a few months.

Why More Attention Is Given to Better Material-Handling Methods

Within the last few years much attention has been paid to individual industrial processes and changes adopted or new methods installed that would show a reduction of costs or an increase in production per man hour or per dollar expended. Under former methods of cost keeping, the material-handling expense was usually lumped under the heading of "indirect labor" or "overhead." In getting a closer analysis of costs, this general term "indirect labor" has been subdivided until now, for analytical purposes, in many instances the management knows which items go to make up this expense and about how much each costs. Such analyses have thrown the spotlight on ma-

The tendency to electrify existing equipment is well shown in this special motor attachment for making a power hoist from standard hand equipment.

Formerly strong men were required to lift these 300-lb. rolls of wire. A shortage of this type of men has forced the installation of these electric hoists, operated by push buttons, so that a smaller man can now do the job much more quickly.

terial-handling costs. However, even these do not disclose all material-handling costs, as many are still covered up as a part of another operation. In this connection, time and motion studies have done much to separate the parts of work which are really handling operations from those which are manufacturing or machine operations.

Probably the most important factor, however, in forcing attention to better material-handling methods has been a decrease in the number of rough laborers available. This is particularly true of what were commonly known in industry as "strong back" jobs. As a result, particularly during the past year, many mechanical devices have been installed in plants which have either eliminated this rough, heavy labor or make it possible for this work to be done at a minimum of physical effort. For example, one of the first places which felt the shortage of this rough labor was in the miscellaneous yard jobs, such as storing coal, handling pig iron, foundry sand or debris, or other similar moving jobs which required a considerable number of men at the same task.

These methods adopted are not new by any means; conditions have simply been favorable to a wider application of such equipment as locomotive, bridge or mono-rail cranes with magnets or grab buckets. Often these cranes and hoists are used in connection with trucks, belt conveyors, or other types of carriers, for the reason that many times the cranes cannot carry the material economically to its final destination. The big saving resulting from the use of a crane, however, is that it picks up tons at a time with only the expenditure of one man's time, whereas men pick up by the shovelful or by the piece. Also, the crane or conveyor can carry a continuous load of tons in the same length of time that one man can carry possibly 200 to 400 lb. at a trip. A large crane or belt conveyor and one man with a wheelbarrow are extremes in output.

An incidental saving as a result of using heavier equipment is the elimination of the expense incidental to the replacement and repairs of shovels, wheelbarrows and other similar equipment which are necessary for the men. This saving, in many cases, amounts to thousands of dollars in addition to the other thousands saved in the wages of each man replaced.

Small Installations Can Make Big Savings

It is not necessary that the installation be large nor cost thousands of dollars to be economically used. Even where only a few carloads of material is handled irregularly, many kinds of portable handling equipment may be used, such as portable belt unloaders, wagon or truck loaders and electric storage battery trucks with special bodies to haul a ton or more at a time instead of wheelbarrow loads.

One of the advantages of using magnets to pick up work is that it is not necessary to call a gang of men nor "fuss" with chains.

Conveyors of belt, apron, bucket and gravity types have played a very prominent part in the reduction of material-handling costs. In one New England factory a system of belt conveyors and pneumatic tubes, costing approximately $75,000, has doubled the output with a reduction of 72 operators and made a saving in labor of approximately $72,000 at an operating cost of approximately $4,000 a year. In any plant where men are continually walking back and forth at their work, a study of the advantages and possibilities of a conveyor for carrying the work between these two points will usually be found profitable.

Conveyors are used not only in moving materials, but also in progressive assemblies and to a large extent recently for temporary storage floors. Conveyors from machine to machine are in one sense a storage conveyor as well as a carrying conveyor. A good example of the use of conveyors for production and for storage was given in INDUSTRIAL ENGINEER, on page 504 of the October issue.

The savings which may be made through material-handling equip-

ment in various combinations are so great that many companies are designing special equipment for their particular problems. Oftentimes this is but a slight variation of existing equipment but enough, however, to require special designs for the installation. Some of the examples illustrating this article show these adaptations of material-handling equipment for special cases that later have been found to be of wide enough use to become a standard type.

Lifting Light Loads Mechanically

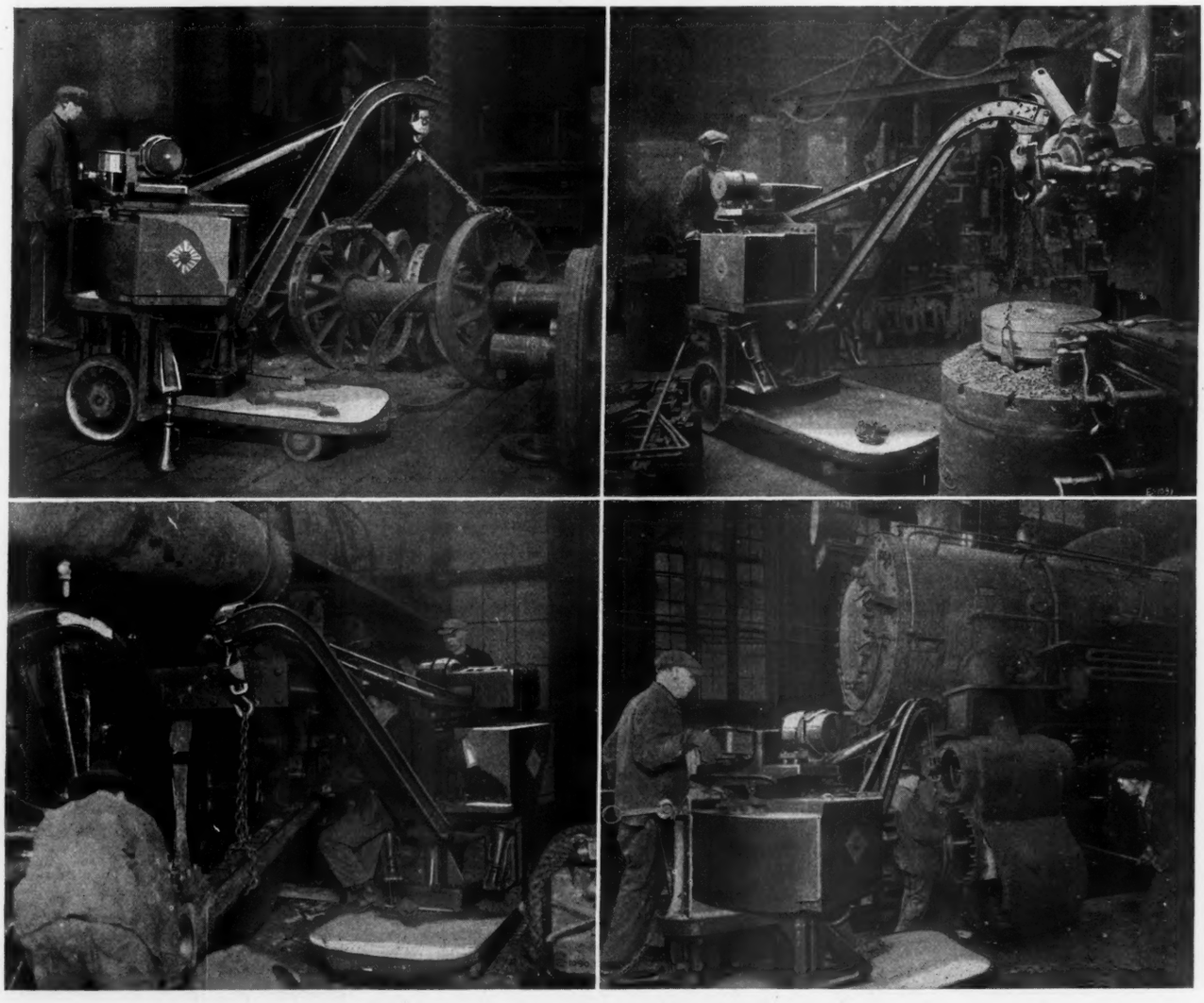
Another feature which has helped to increase and speed up production, as well as eliminate the number of men required, is the addition of numerous small hoisting units in a shop to supplement the large overhead traveling crane. In many plants where one large traveling crane had been installed large enough to take care of a wide range of work, it spends most of its time on light jobs. An auxiliary installation of small hoists to serve machines leaves the heavier and more powerful equipment for the heavy work which it alone can do.

The wide demand for equipment for this purpose has led to the electrification of three types of light machines. Several electric hoist manufacturers have developed light electric hoists of approximately ½ to 1 ton capacity to take their power from an extension cord.

Similarly the Economy Engineering Company, Chicago, has recently electrified many installations of its small portable elevators up to 1,500 lb. rating where they had been sold for hand operation. These also take power from a socket. Another company, The Motorbloc Corporation, Philadelphia, Pa., has designed a special electrical motor attachment to be placed on standard hand-operated hoists to electrify them. This is controlled from a push lever mechanism held in the hand and receives power from an extension cord. Numerous other similar applications of material-handling equipment which add to their flexibility have been designed recently in response to the demand for increasing production, eliminating extra labor and reducing costs.

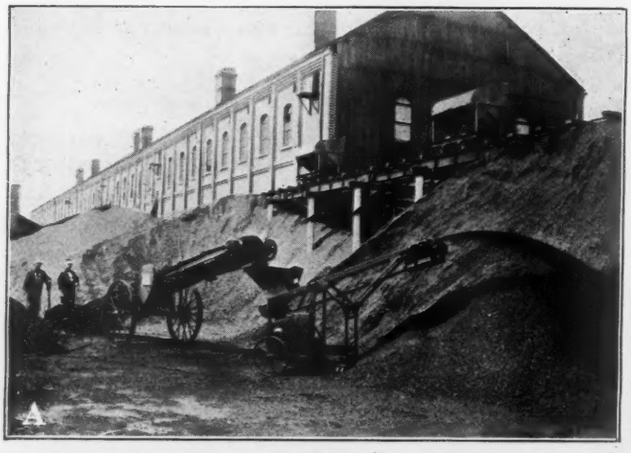
One Method of Increasing Speed

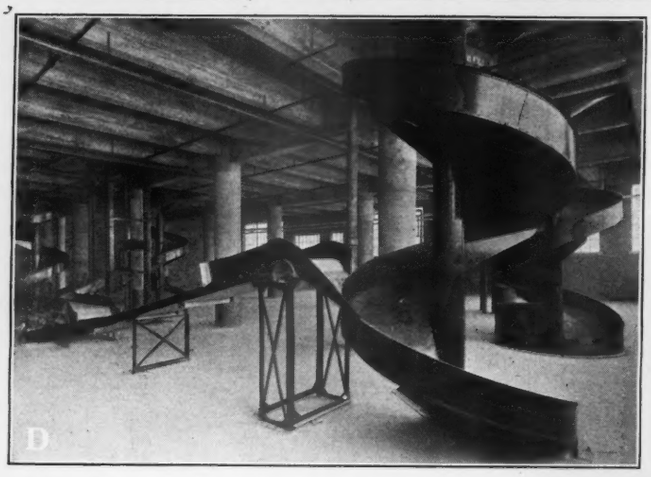
Many overhead cranes designed during the past year have been for high-speed operation. One crane user, A. L. Gear, chief electrician of the Gary Screw and Bolt Company, Gary, Indiana, has re-designed his equipment to get not only a higher speed but operation at two speeds. Mr. Gear realized that while a crane was designed for handling its rated load, only seldom was the actual load ever up to anywhere near its maximum rating. By dividing and reconnecting the fields of the direct current hoist motors, the crane was speeded up for handling the light loads which comprise the larger percentage of the work. Through special connections in the



Nine Material-Handling Operations

Showing Ways Work Has Been Speeded Up at Lower Cost





A—If these Link-Belt portable belt conveyors earn their way handling coal in Japan, where labor is cheap, what might they do here?

B—Big gantry cranes like this Meade-Morrison installation take the place of hundreds of men.

C—This Cowan electric lift truck speeds the "peddling" of supplies at a low labor cost.

D—Alvey-Ferguson spiral chutes, belt and vertical conveyors supplant trucking in this flour mill.

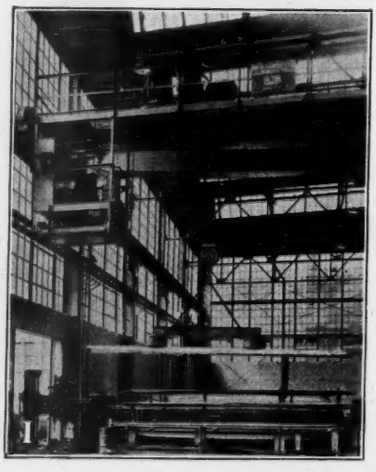
E—This McKinney-Harrington portable conveyor handles supplies to and from a balcony storeroom.

F—Rolls of metal strips are handled to and from annealing furnaces by this Baker R & L special tiering truck.

G—The strength of a man is multiplied many times by this Shepard hoist.

H—A modification of the electric lift truck (Elwell-Parker) handles crucibles to and from an annealing furnace.

I—One floorman and the crane operator "pick" stock in this steel warehouse with this Ohio Electric crane and magnet. The two men supplant a gang.



cab the crane man can operate the crane either at its designed speed or at the increased speed by simply throwing switches. Light loads are now hoisted at double speed. This has resulted in increasing the capacity of the crane by about 40 per cent. This crane is used for loading scrap with a magnet and for unloading steel rods and bars from cars. This one crane was re-designed as an experiment. Mr. Gear believes that for general operating practice it would probably be better to increase the speed of this motor only about 25 to 35 per cent instead of 50 per cent. The bridge and trolley motors were not changed.

Light Lift-and-Carry Equipment

For certain lines of work, combination or two-operation (lift and carry) equipment has established a firm place in industrial works. Perhaps the most common examples of this type are the hand and electric elevating-platform trucks. These are so common as to hardly need description. But few users realize, however, their wide application. Wherever material must be moved over varying routes or when handled intermittently in moderate quantities, it always pays to investigate the applicability of either hand or power elevating platform trucks or a combination of the two with possibly tractors and trailers if the material is hauled any distance. Very large quantities handled over a definite route usually are more economically handled by permanent equipment such as conveyors or cranes.

The most important feature in increasing the use of lift-and-carry equipment is in providing suitable types of skids or platforms. For example, carefully machined parts which might be damaged if permitted to come in contact with each other are easily protected by placing them on a special skid designed to separate each part. For example, one large automobile company saved thousands of dollars in one year by the use of these special skids over the former practice of throwing these parts into tote boxes. For example, a machined crankshaft represents considerable time and labor and can easily be damaged by being piled in promiscuously with other crankshafts. The saving of only a few crankshafts would soon pay for the extra expense of making the special skids for handling this work. Literally hundreds of special designs for skids have been made for the solution of particular problems in various industrial plants. Some have and others will be illustrated frequently in the "Handling Materials" department of the INDUSTRIAL ENGINEER.

At first skids were plain, home-made wooden frames. Now the tendency is to use a much heavier and more substantially built platform with steel or iron supports or legs bolted securely to the platform. Practically all elevating-platform truck manufacturers supply substantial skids of this type "knocked down" for shipment. The use of pressed steel skids is also increasing. While these were originally used for handling hot forgings, they are now quite commonly used for any heavy, rough materials such as castings or machine parts which are not damaged through contact with each other and are very abrasive to the wooden platform.

Tiering or piling trucks, which lift their load several feet instead of a few inches, and carry as well, are a development of the electric lift platform truck and the portable elevator or tiering machine. These are now used quite extensively for picking up material and piling it to the ceiling, several layers high by not more than one man and the operator, where formerly a large gang of men were required to do the same work. Some printing concerns are using these machines to pile box or roll paper to the ceiling and also to pile two or more skids loaded with printed and folded sheets on top of each other and so economize in storage space. One concern, instead of piling, suspends the upper, loaded skid from the ceiling. Instead of tiering trucks, portable elevators are very often used in combination with either hand or power lift trucks.

Cranes on Trucks as a Shop Tool

Although electric trucks with a crane hoist built on the platform have been on the market for a number of years, their application has increased within the last year. These have a wide application and in many plants they are considered one of the shop tools, as they are used to load small machine tools, to lift equipment and other parts when they are handled by the Maintenance Department, to set and remove dies, to pile material in the yard, to load and unload heavy castings or incoming material onto either industrial trucks or motor trucks, and many similar tasks. Railroad shops are using these to particularly good advantage, for example, in such jobs as removing cylinder heads, connecting rods and other pieces which are far too heavy to be handled by any less than two or three men. Without some such arrangement as this it would be necessary to rig up a chain hoist for each of these operations. The storage-battery truck with a crane can pick these parts up anywhere and carry them to the shop or to the locomotive, or assist in this (*Continued on page* 47)

Installations are more flexible if they are designed so that they can be used in connection with any equipment. This lift truck platform skid has wheels so that it may be moved by hand; chains enable it to be lifted by the shop crane.

Kinds of Dirt Encountered When

Cleaning Lamps and Reflectors

In Works of Various Industries and How They Can Be Most EffectivelyRemoved

By N. T. GORDON

Experimental Engineering Laboratory, National Lamp Works of General Electric Co.

Plenty of soap and water is usually sufficient but, for oil and grease, Bon Ami, Old Dutch or Babbitt's Cleansers will speed up the job.

LIGHTING men know that the amount of illumination obtained from lighting equipment decreases gradually but surely with length of service, due to the dust and dirt which accumulate on the surfaces of the lamp and the reflector. A few months ago an investigation was undertaken to classify the kinds of dirt which may be expected to accumulate on the lamps in representative industries and to determine just how much the light output of lamps may be increased by cleaning them.

To determine the kinds of dirt to be found on lamps in regular use in the various industries, several companies were visited and from one to three lamps taken from each. The companies visited were representative of the automobile, paint and varnish, chemical and storage battery industries, machine shops, foundries, transportation offices and warehouses. In general, lamps were selected which had accumulated dust and dirt typical of each industry.

The total number of lamps used by these companies is approximately 16,000, about 85 per cent of which are clear lamps. Of the companies visited, 60 per cent do not clean their lamps at all, 33 per cent clean them at infrequent intervals and about 7 per cent clean lamps frequently at regular intervals. It should be borne in mind that this survey was made at a time of financial stringency, when many of the companies were operating only three or four days a week, with reduced forces. Maintenance men whose duties include regular cleaning of the lighting installations had been temporarily released and a much higher percentage of companies which clean lamps frequently can be expected when these men return to work under normal manufacturing conditions. Typical cleaning materials found in use at the companies visited were soap and water, Gold Dust and Oakite.

Tables I and II show the kinds of dirt found in twenty-four different service locations and the foot-candle measurements, taken from a fixed position, before and after cleaning the lamps. All but two were clear lamps; these two were bowl-frosted lamps.

It will be seen from the two tables that four separate classes of dirt were encountered; namely, dust and dry dirt, smoke, and so on; oily dirt and grease; paints, tars, varnish and pitches, and acid fumes. These are given in the order in which they most frequently occur: Ordinary dirt is encountered more frequently than paints, tars or pitches, even though more lamps were selected in the latter class.

By wiping the lamps taken for this test, it was possible to increase their average light output 68.6 per cent. When they were washed they showed a total increase of 86.3 per cent in illumination. The increase in the case of those soiled with oily dirt was 147 per cent. Emphasis should be given to the fact that these figures represent the increase in light due to cleaning the lamps only. A much greater increase in useful light will result when the whole lighting unit is cleaned. Hence, the figures in Table II show very plainly that the regular cleaning, at stated intervals, of lamps and reflectors is necessary in order to avoid much waste of electrical energy and light.

The preceding paragraphs emphasize the fact that when lamps are not cleaned regularly they become very dirty, and the data given in the tables for lamps under service conditions demonstrate the surprising increase in illumination caused by cleaning. Inasmuch as it is necessary to clean lamps frequently at regular intervals, it may be ques-

tioned how the different classes of dirt are removed by progressive maintenance men. The answer is simple, because by far the greatest number of lamps may be cleaned by the application of soap and water. Dust and dry dirt, as well as oily dirt and grease, are removed by this method. It will be found easier, however, to remove fly specks, smoke, oil and grease by the application of some cleaning agent such as Bon Ami, Old Dutch Cleanser, or Babbitt's Cleanser. The procedure for a thorough job of cleaning usually involves the removal of a group of both lamps and reflectors to a central location for washing. If desired, lamps and reflectors may be cleaned without removal from the sockets, but the results are usually not as satisfactory. After washing it is important to dry the lamps and reflectors with a cloth or in dust-free air.

Paints, tars and pitches are encountered comparatively infrequently, but are sometimes very difficult to remove by the usual methods. In these cases an organic solvent such as acetone, fusel oil or benzol will usually remove the dirt quite easily, but caution is necessary in using them. Many organic solvents are highly inflammable and their use should be carefully supervised.

It is the experience of the writer that a fair trial of the frequent application of soap and water for cleaning lamps and reflectors will reveal a surprising increase of illumination and result in a verdict demanding proper maintenance of lighting equipment.

Table I.—Increase in Illumination Obtained by Removing Various Kinds of Dirt from Lamps in Service

Lamp No.	Watts	Kind of Dirt on Lamp	Before Cleaning (Foot-candles)	After Wiping (Foot-candles)	Increase in Illumination, Per Cent	After Washing (Foot-candles)	Increase in Illumination, Per Cent
1	200	Dry machine shop dirt	14.0	23.0	64	23.0	64
2	100	Rosin vapor	.....	.....	Filament broken	.....	.....
3	200	Dry machine shop dirt	5.5	16.0	191	16.0	191
4	75	Smoke and dust	8.0	11.0	38	11.0	38
5	40	Smoke and dust	4.5	8.5	89	8.5	89
6	40	Acid fumes	7.0	11.0	57	11.0	57
7	200	Fly specks and office dirt	11.5	14.0	22	16.0	39
8	100	Rosin vapor	2.75	3.75	36	3.75	36
9	50	Linseed oil	1.75	2.75	57	2.75	57
10	150	Coke, lamp black, graphite dust	8.0	17.0	112	17.0	112
11	40	Dust and vapor from lamp black manufacture	2.75	4.5	64	4.5	64
12	40	Dust and vapor from lamp black manufacture	2.0	3.75	87	3.75	87
13	100	Dust and vapor from coke, pitch and lamp black	.....	.....	Filament broken	.....	.....
14	100	Coke dust	2.75	6.5	136	6.5	136
15	100	Carbon and pitch	.....	.....	Filament broken	.....	.....
16	25	Oily dirt from lathes	1.5	2.75	83	5.0	234
17	25	Oily dirt from lathes	2.2	4.5	104	5.5	150
18	100	Asphaltum vapors	8.5	11.0	29	11.0	29
19	100	Gum vapors	5.5	8.0	45	10.0	82
20	40	Dust from paint mixing	.....	.....	Filament broken	.....	.....
21	40	Rosin vapor	.....	.....	Filament broken	.....	.....
22	40	Paint	3.6	5.5	39	8.0*	122
23	60	Dry gypsum dust	8.0	10.0	25	10.0	25
24	60	Dry gypsum dust	11.0	14.0	27	14.0	27
		Averages	.....	.....	68.6	.....	86.3

*Organic solvent used in cleaning this lamp.

Table II.—Summary of Illumination Increases

	Kind of Dirt on Lamp	Average Per Cent Increase in Illumination After Wiping	Average Per Cent Increase in Illumination After Washing
1	Dust and dry dirt	77.7	78.4
2	Oily dirt	84.7	147.0
3	Paints, tars and pitches	37.2	67.2
4	Acid fumes*	....	....
5	All lamps	68.6	86.3

*Bulbs were badly attacked by hydrofluoric acid and bases badly corroded by muriatic and nitric acids; therefore candlepower measurements were not included.

Better Methods of Handling Materials

(*Continued from page* 45)

installation by lifting them to the required position.

Many special adaptations have been evolved. One of the best known of these is the furnace-charging truck which has now become a standard type. The platform on this is merely a set of prongs extending forward from the truck. These are run under an annealing pot and lifted as with the ordinary lift truck. The pot is then moved anywhere and deposited in the annealing furnace. This is also used for discharging the furnace and can be operated when the furnace is even too hot for a man to enter and remove the pot in any other way. With this equipment a furnace can be charged or emptied within a few hours. A slight modification of this truck has been especially designed to use in lifting heavy boxes. Another modification is used to handle rolls of paper.

As stated before in this article, no one type of material-handling equipment is always best, particularly when it is installed in an existing plant with limitations in the construction of the building and the arrangement of the departments. In such a case it is well to make provisions so that the material can be handled by any or all of the different

(*Continued on page* 67)

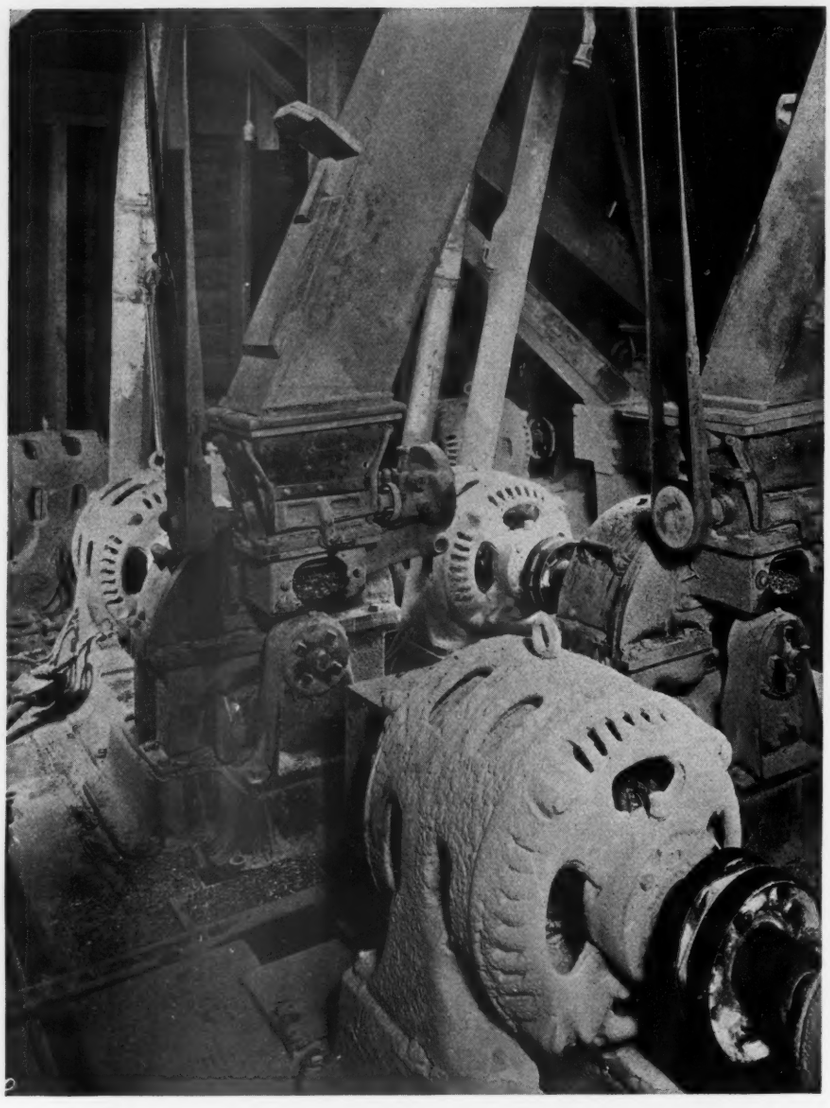
THE FUNCTION of maintenance is to keep electrical and mechanical equipment at a high level of efficiency, for the purpose of securing maximum production at the lowest operating cost. Accomplishment of this function depends on three factors: (1) Continuity of operation in the path of power service. (2) Prevention of avoidable causes of failure of equipment. (3) Conservation of equipment by proper care and periodic overhauling. Analyses of maintenance work are given in this article under each of these headings.

Some Whys and Hows of

Maintenance Analyses and Procedure

And Information Needed Before an Effective Maintenance Plan Can Be Laid Out

By G. A. VAN BRUNT
Managing Editor, Industrial Engineer



The need for inspection and cleaning of motors under operating conditions such as shown here is self-evident. Without it continuous motor service is simply a matter of good luck rather than foresight

FROM a production standpoint the function of maintenance in plant operation is to keep the equipment on a high level of electrical and mechanical efficiency and thus make it possible to secure maximum and, so far as possible, uninterrupted production at minimum cost. The fulfillment of this function is primarily dependent on the recognition and thorough and proper analysis of three essential factors:

(1) Continuity of operation in the path of power service that extends from the point where electrical energy is received in the plant to the pulley of the machine where this service is used in machine production, or the point where this service is transferred or taken up by a machine and an operator, or by a process and a chain of machines, in the details of making a particular product or parts of it.

(2) Prevention of avoidable causes of expensive failures by the prompt detection of all weak parts and indications of wrong applications or abuse, by observation and inspection of equipment while in operation.

(3) Conservation of equipment from deterioration caused by natural wear and tear, through periodic overhauling, by proper attention to lubrication, and the immediate renewal or repair of broken parts or those that show defects which make further operation hazardous.

Maintenance Embraces Inspection and Repairs

Effective organization for maintenance work must be based on a clear conception of the problems in hand, as indicated by the number and character of the machines and auxiliary equipment, the nature of the product and the character of the production processes, figures on machine production, speeds and other data, as well as costs per hour and per unit of production. With these elements in mind, there must also be made a thorough pre-analysis of the probable weak points and causes of failure in various pieces of equipment, with a careful reckoning of the consequences of such failure, in order that the work may be properly directed and emphasis placed where it belongs. A production chain is no stronger than the weakest part of the drive and control equipment through which power service is supplied to the machines in this chain.

The procedure of maintenance work involves systematic and thorough inspection of all equipment by competent workmen and at intervals which in view of service conditions

are short enough to locate weak spots before an actual failure takes place. It also involves provision of the proper facilities for making necessary repairs or adjustments either with the equipment in place or after it has been removed to a repair shop, if much work has to be done on it.

Inspection consists, of course, of a careful examination of equipment for the purpose of determining whether defects are present and in keeping a close watch of the operating condition of equipment and parts where trouble is most likely to develop. Some pieces of equipment and certain elements of each piece are much more liable to develop trouble than others; therefore in many cases a unit may be given a thorough going over once a week or once a month, while the inspector on his daily rounds will examine only those parts of it which are prone to develop trouble quickly. For example, the monthly examination of a motor and its control may involve testing the air gaps, careful examination of commutator and brushes, listening for unusual noises, smoothing contact surfaces of the line switch and starter, and so on. In the daily round he may merely feel of the motor bearings and coils to see if there is undue heating, and observe the operation for a moment to see that it is normal.

Inspection Schedules Should Be Based on a Thorough Knowledge of Conditions

The frequency and thoroughness of inspection depends in general on the severity of service conditions and also on the importance of continuity of operation. These factors and any others which are pertinent should be carefully considered when an inspection program is being laid down. In cement mills, for example, the air is constantly filled with a fine, more or less abrasive dust which rapidly cuts out bearings and wears down the commutator and all other moving parts. On the other hand, the failure of certain motors would seriously interfere with production by making it necessary to shut down other machines in order to prevent the piling up at certain points of materials in process.

Under these conditions, frequent and thorough inspection of all motors is essential for the continuity of production and the prevention of serious damage to the motors. In one representative cement mill, for example, where 235 motors are in operation, each one is carefully inspected eight times every twenty-four hours by a corps of three inspectors who work in 8-hour shifts, so that an inspector is always on duty.

The inspector on the first shift starts at 7:30 a. m. and works until 3:30 p. m. He is required to inspect every motor in the plant twice during this period. These inspections include feeling the bearings to detect undue heating, looking at the commutators and brushes, examining starting boxes, switches and fuses and checking the air gaps of the motors. In addition he replaces short or defective brushes. An average of forty brushes is replaced each day. Incidentally, brushes are replaced and the air gaps tested while the equipment is in operation. The inspector on the second shift, from 3:30 p. m. to 11:30 p. m., makes three complete rounds of the plant and oils all of the motors, besides inspecting commutators, brushes, switches and fuses, and feeling of the bearings for heating.

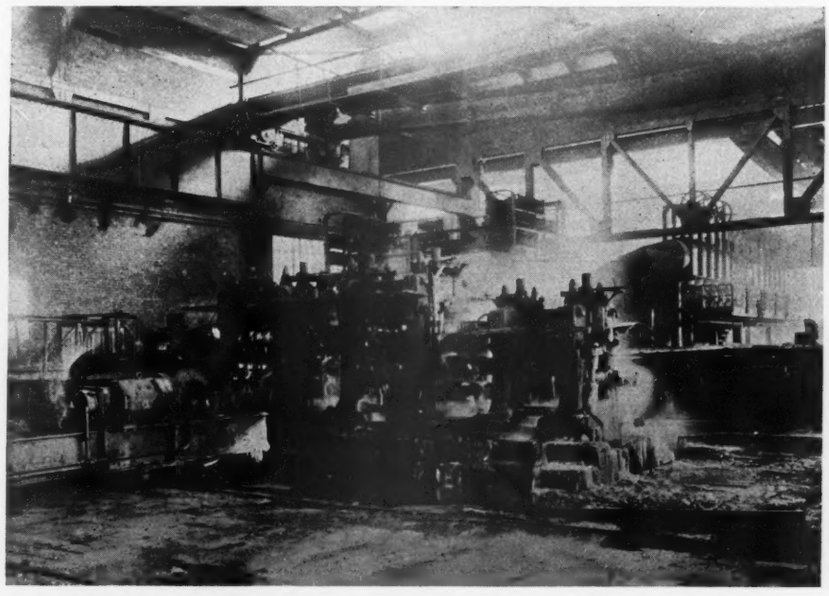
On the third shift, extending from 11:30 p. m. to 7:30 a. m., the inspector makes three complete rounds and handles any emergency repair work such as changing brushes, and so on. So far as possible, heavy repair work and replacement of equipment is done only in the day time; therefore, before the inspector on the third shift goes off duty in the morning he notifies the chief electrician of any equipment which needs immediate attention.

Aside from the three inspectors whose duties have been outlined, heavy repairs and replacements are handled by a maintenance crew consisting of an assistant chief electrician and four men. These men change armatures and bearings, wind armatures and field coils, prepare bearings, turn armature shafts, repair starting boxes and do any other repair work that turns up.

Electrical Equipment in Steel Mills Is Given Unusually Hard Service

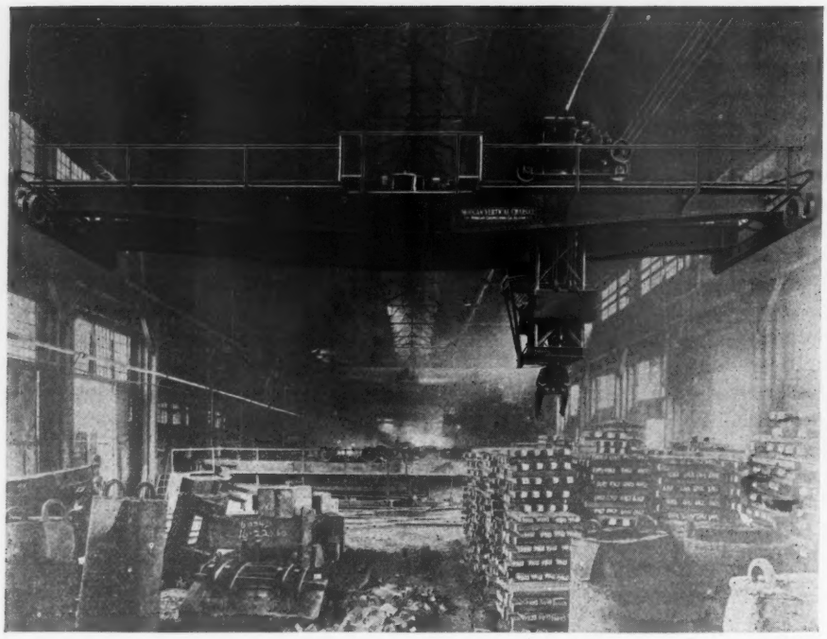
Very severe, but different operating conditions are met in steel mills. Here the units are for the most part large, while the loads are heavy and subject to wide and rapid fluctuations which put unusual stresses on bearings, pinions and other parts of the system. In addition, the direction of rotation of many of the motors is frequently and quickly reversed, which increases wear and tear. There is less dust and abrasive matter in the air than is found in cement mills, but the combination of steamy or greasy atmosphere with metal and carbon dust, derived in part from the brushes on the machines, causes a good deal of trouble. Unless this dust is removed frequently it will form a leakage path between the slip rings and may break down and cause flashovers when an attempt is made to start the motor.

Another condition which adds to



Steel mill motors are often exposed to extremes of heat and cold and dampness.

This is an 18-in. structural mill, comprising two 3-high and one 2-high roll stands, capable of rolling 7-in. I-beams and 4-in. by 4-in. angles. This mill is located in the South Bethlehem, Pa., plant of the Bethlehem Steel Co.



Failure of this crane may cause serious delay and loss.

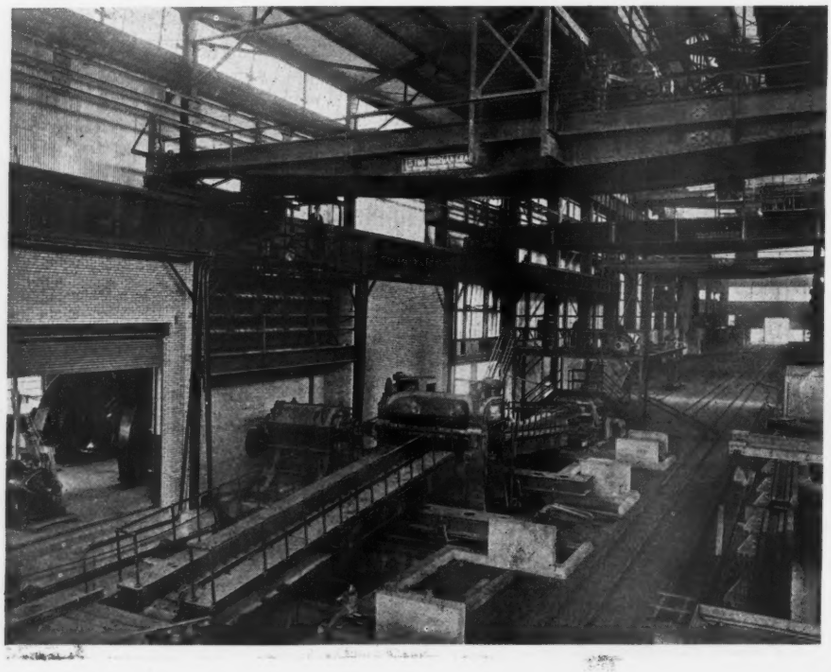
This is a 7½-ton, stiff-leg type crane, with a 60-ft. span and equipped with five motors. It handles hot metal in and out of the soaking pits in the plant of the United Alloy Steel Corporation, Canton, Ohio.

the severity of the service is the constant starting and stopping, so that the motors, in many instances, operate a large part of the time under starting conditions. This means that commutation is poorer than in the case of motors which operate more or less continuously, and that all parts of the machine are subjected to unusually hard duty.

Again, motors in some locations, for example, around furnaces or on cranes which handle ladles of molten metal, are exposed to comparatively high temperatures, a condition which is not conducive to long life.

Here, also, the failure of an important crane or mill motor may not only produce a serious break in the chain of production, but cause considerable loss by leaving tons of hot metal in a partially finished state.

In order to prevent such occurrences, a close watch in the form of daily inspection and cleaning must be kept of all motors and control equipment. As an example of what this involves, the schedule followed in one large steel mill is of interest. A daily inspection is made of all important equipment to detect any symptoms of trouble in operation. In addition to the inspection, once each week all motors, controllers and switchboards are cleaned, carefully inspected and any worn or defective parts repaired or replaced. Every two weeks the air gaps on all motors are tested, all master and drum controllers overhauled, and the operation of magnetic controls inspected. Magnetic controls are carefully inspected and all circuit breakers overhauled at intervals of three weeks. At four-week periods the collector rings are cleaned, oil switches and brushes on all apparatus, including motors, overhauled, all motors are tightened up, pulleys and couplings inspected, rotary, direct-current breakers tested and the voltage drop on all circuit breakers determined. Other inspection, testing or overhauling operations are scheduled at intervals of six weeks, two months, three months, and so on.



A 30-in., 3-high billet mill.

This mill is equipped with combination tilting, lifting and traveling tables. It is located in the Lebanon, Pa., plant of the Bethlehem Steel Company and is used for reducing 14-in. by 14-in. ingots down to 2½-in. to 4-in. billet. The motor is protected by housing it in a separate room.

Material-Handling Equipment May Be the Key to Continuous Production

In the instances which have just been cited particular emphasis is placed on keeping in service the motors driving the various machines in the production scheme. Sometimes, as in the case of plants which turn out a very bulky or heavy product, the key to continuous production lies in the cranes or similar material-handling equipment which is employed to transport the product or its component parts from one machine or operation to another. Under these conditions, while the failure of a motor driving a machine tool may cause annoying delays and loss of production, it will usually not be so serious as the failure of a crane which serves a number of machines. In this case all of these machines may have to stand idle until the necessary repairs can be made and the crane put into service again.

An example of these conditions is found in a large plant which makes screws and bolts exclusively. Practically all of the raw material and finished product is handled to and from the machines by eight electrically-driven traveling cranes, several

of which serve a number of machines. Inasmuch as the failure of one of these cranes will tie up production in a very short time, every effort is made to keep the cranes in good operating condition at all times. To this end a very thorough inspection of all cranes is made every Friday. At this time the motors, brushes, switches, controller, gears, bearings, tracks and wheels, sheaves, hooks and chains, in fact every part, of the crane is carefully examined and an inspection report form made out showing the condition of these parts. These report forms are given to the assistant chief electrician. He notes the items carefully and turns them over to the chief electrician, who checks in red the repairs he wishes to have made at once. In this way both the assistant and the chief electrician have at all times an accurate knowledge of the condition of the cranes and the extent and character of the repairs which are necessary.

This should not be taken to mean that the motors and controls of the machines which turn out the plant's product are neglected. These are subjected to an inspection routine which is adequate and rigidly enforced. But, as is proper, more emphasis is placed on keeping the cranes, which are the key to the production program, in the best possible working order.

Somewhat different conditions obtain in plants where each machine turns out a product that is either practically ready for the market, or is sent to stock to be withdrawn later on. In such cases the loss of the services of one or two machines through failure of the motor or other power equipment will not seriously interfere with the production of the plant as a whole. A case in point is found in a certain plant whose product consists of a large number of small parts. Practically all machines are individually driven and with a few exceptions a number of machines are employed to turn out the same part. As they come from the machines all parts are sent directly to the stockroom and withdrawn in accordance with the needs of the assembly department. A sufficiently large stock of each part to supply the assembly department for some time is kept on hand; therefore, the failure of a motor which drives one of the lathes or punch presses is not immediately serious, from the production standpoint. Of course, failures are expensive under any circumstances, in that it costs money to replace and repair a motor and to have workmen and machines stand idle, and every reasonable precaution is taken to avoid them. In this plant, experience coupled with a careful balancing of the cost of inspection against the probable frequency and seriousness of motor failures has shown that a careful examination of all motors once or twice a week, with a complete overhauling every six months, will serve to keep them in good condition and reduce to a minimum the failures from preventable causes.

Written Schedules for Maintenance Work Avoid Confusion and Fix Responsibility

After the analysis of the objects to be accomplished and the decision as to the methods of attacking the problems, there must be provided schedules or written instructions covering: (1) Daily routine duties; (2) periodic inspections of machines and equipment; (3) periodic overhauling of machines and equipment; (4) procedure for scrapping or placing any piece of equipment on the obsolete list. Unless this is done, vital points in the maintenance program are almost certain to be overlooked or misunderstood and it will be difficult to fix responsibilities definitely. Some system of inspection and repair reports must also be worked out in order that a proper check can be kept on the work. In the absence of some method of checking, interest will lag, the hard jobs will be overlooked or slighted and haphazard guesswork will take the place of the definite, clear-cut methods of procedure which are essential if the desired results are to be obtained.

This does not mean that maintenance work should be bound up hand and foot with red tape. It is unreasonable to ask a man who is inspecting every motor in a large plant three times a day to make a detailed report of each inspection. It is just as bad, or worse, not to require any reports. It is possible, however, to work out, somewhere between these extremes, a system of inspection reports which will be adequate under the character of the operating conditions which obtain.

For example, in one plant which operates a large number of small and medium-size motors, the inspection schedule calls for a thorough examination of each motor once a week. Most of the machines in this plant are individually driven, and inasmuch as the service conditions are not unduly severe, a weekly inspection has been found to be satisfactory. The inspector carries with him in his rounds a report form on which is entered the number of each motor. Opposite this number there are four columns, each headed by the date on which the inspection is made. (*Continued on page* 65)

Lack of attention to motors operated under conditions like this is the cause of high repair bills.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, January, 1923

A Happy New Year to You All

FOR INDUSTRIAL ENGINEER this issue marks its first birthday under that name and its present scope of service to men in industrial works. The occasion is a particularly fitting one as we look into a new year with new hope and new inspiration, to express appreciation for the full measure of co-operation that 127 contributors have given us during the year past and to wish for the 15,000 men who make up our family of readers Health, Happiness and Prosperity during the year we are just beginning.

An Ounce of Inspection vs. A Pound of Repair

CONCLUSIVE proof of the value of organized inspection and maintenance work in preventing failures and reducing the cost of repairs to equipment was recently obtained by a well-known company, which operates about 3,000 motors and 300 traveling cranes in a works covering many acres of ground.

When the business depression came very radical reductions were made in the number of employes, particularly "non-producing" labor. Most of the electrical department inspection and repair crews were included in this category and in consequence systematic maintenance work was practically abandoned. As was to be expected, the power and control equipment got into such bad shape that when business revived the necessity for proper inspection and repair work could not be denied.

After a thorough study of the situation a carefully planned schedule of inspection, cleaning and oiling of all electrical equipment was instituted. When it had been in effect for some months, the cost of inspection, oiling and cleaning was found to be about $1.50 per motor per month. The credit side of the ledger showed that the shutdowns due to failures of electrical equipment had been reduced 75 per cent. In other words, three failures out of four could be prevented by spending $1.50 per month in maintenance work. Anyone who is responsible for production or maintenance knows that even a minor breakdown of a motor or other interruption to power service may cost many times this amount.

With some variation in details this same incident has been, or could be, told of nearly every industrial works. It is cited as showing the fundamental truth of the saying: "An ounce of prevention is worth a pound of cure," which bit of wisdom is so old that apparently its very antiquity sometimes keeps it from being taken seriously.

The Remedy for Breakdown Alibis

IN a recent address on "Conservation of Plant and Equipment," Emil J. Schmidt, Industrial Engineer with Sewell-Clapp Envelopes of Chicago, started out with this sentence: "A smooth running plant is no accident." Then he proceeded to analyze the vital steps embraced in conservation and in dealing with plant operation, he said:

> "How is maintenance handled? Is there a separate department for it? How is it controlled? What equipment in particular has the maintenance department for doing its own work? We need all the available figures on machine production, speeds and other machine data, costs per hour and per unit of production.
>
> Get the facts! All the facts! Analyze the facts! The management is then in a position for setting standards, based on definite policies. These had better be written, to be clear and concise. Standards would include performance, maintenance expense and also standards of supervision.
>
> Schedules or written instructions can then be provided for: (a) Daily routine duties of functions in maintenance work; (b) Periodic inspection of machines and equipment; (c) Periodic overhauling of machines and equipment; (d) Procedure to be followed when any piece of equipment is scrapped or placed on the obsolete list.
>
> The best system, the most alert executive, will not succeed fully without co-operation. This is particularly true of maintenance work. The engineering department, superintendents, foremen, all must co-operate fully in order that the maintenance department can really do all that the executive expects. The first-class executive (and this is the only kind that we are discussing) knows this, and he will see to it that co-operation is secured.
>
> In all of this, if it is to be thoroughly analyzed and handled, need we say that the industrial engineer, or someone who has his viewpoint and uses his technique, is absolutely indispensable?

Unquestionably it is this kind of thinking that is most needed in all industrial works where new production schedules and new plans are being laid on which future profits will depend. This thinking from a production standpoint must be injected all along the line from the receipt of an order from a customer down through all the processes to the shipping platform. In this issue another phase of the same thinking is taken up by Arthur J. Whitcomb. In the first of four articles he lays down the basis for an accounting of maintenance procedure while the work is going on as a perpetual check on the cost of the unexpected that shows up in breakdowns, losses in production at machines and in entire departments. Such an index to production costs cannot be figured accurately in advance but the data from a perpetual accounting of procedure in maintenance will show up certain plant deficiencies in equipment and methods without the painful post mortems at the end of each quarter of the year when

discussions on dividends bring up facts and figures and plenty of alibis and explanations for the things they should not show.

Key Motor Installations

IN HIS contribution to our analysis of maintenance practices presented in the table on page 32 of this issue, J. H. Gallant, Chief Electrician of the Canada Cement Company, Belleville, Ontario, uses the term "Key motor installations." He applies it to the use of motors on conveyors, elevators and the like, which carry materials or parts in process to or from machines or other departments.

This is a very apt term. It calls attention to a point in the chain of power service in any works where this sort of equipment is installed, that must be strong enough to take more than ordinary jolts during its entire period of service. When equipment is new and running nicely, failures at these points are not expected, but the inevitable weakening as the result of natural wear and tear must be taken into consideration if the strength of this link in the chain is to be maintained at its original value. This means regular and periodic inspections, replacement of worn and weak parts as the inspectors locate them; and a thorough overhauling at such intervals as the records of inspections will indicate are necessary.

It is an unfortunate condition when these key motor installations are ignored until a breakdown takes place, for then an emergency situation is created that must be attended to like a fire with an unavoidable waste in production, time and often materials in process, especially when hot metals are being handled—a waste that depends entirely upon how quickly steps in repair can be set in operation. The old saying that "A stitch in time will save nine," is a good one to put into actual practice in the maintenance of these key motor installations.

Is Maintenance Work a Luxury or a Necessity?

IN A CONVERSATION with an engineer who has had many years of experience in maintenance work, he recently said: "When a man has to fight with his boss at every turn of the road to get permission to do his work properly, he surely has a life-sized job on his hands." The truth of this statement is apparent without argument or demonstration. Anyone who is handling a real job in the way it should be handled usually has his full share of burdens, under the best of circumstances. But if, in addition to his work, he has to contend with a hostile, penny-wise-and-pound-foolish managerial policy, his load is increased manyfold.

Failure to appreciate the importance of maintenance work is, no doubt, often due to the fact that it is hard to show in dollars and cents just what the returns are. Maintenance is not a gold bond bearing a guaranteed rate of interest, payable quarterly. It is insurance against costly interruptions of production through the failure of equipment. It has justified itself if it has kept the wheels turning by the elimination of all preventable causes of failure. Some conception of the value of maintenance work can be obtained by calculating what it would mean in loss of production, wages of idle employes and so on, to lose through breakdowns the service of an important motor and its driven machine for one hour. If this were an actual occurrence there would have been added to the above figure the cost of repairing the motor, which might easily amount to a hundred or more dollars. While this is not an insignificant item, the other losses may be much greater unless production can be started again either through the substitution of auxiliary or stand-by equipment. A few such failures in the course of a year would pay for a good deal of maintenance work. Needless to say these truths are just as applicable to the maintenance of lighting, call or alarm systems and similar factors as to motors and the mechanical equipment with which they are associated.

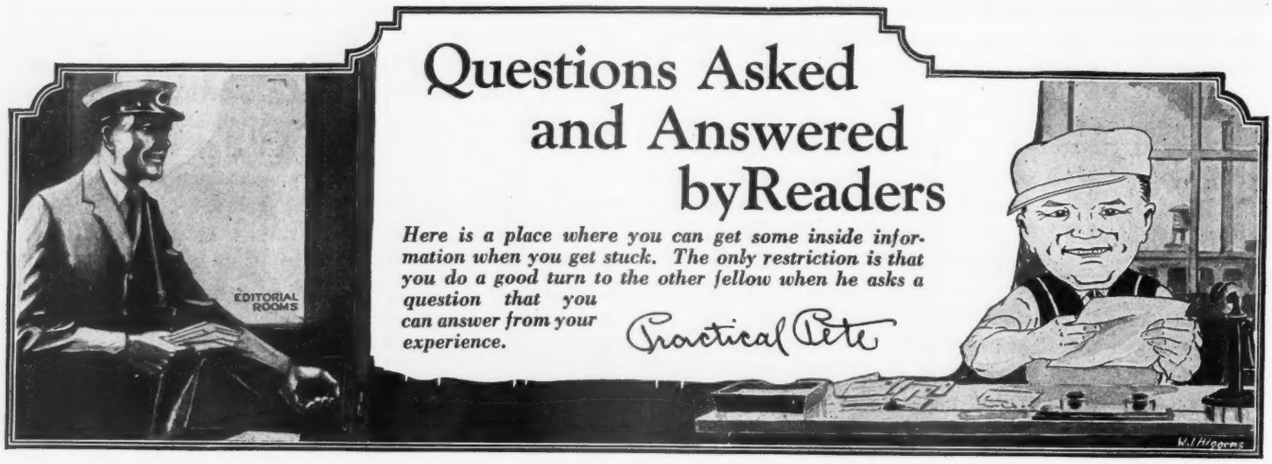
The Aim of This Issue

THIS ISSUE of INDUSTRIAL ENGINEER starts the second year of its service to men in industrial works responsible for the operation and maintenance of electrical and associated mechanical systems. In the twelve issues that have gone before, specific instances have been dealt with where special attention has been directed toward maintenance thinking and maintenance needs, and information given on the analysis of the work involved and the results secured. In each case the "hows" and the "whys" of maintenance have been discussed so that the men who are planning this work and those who are carrying out the details can go where they are looking and look where they are going in contrast with the futility of the blind trying to lead the blind.

In studying maintenance problems during the past twelve months the occasion has repeatedly come up to compare the methods followed in one large works with those of another and the results of each. In every case the variations in the results secured seem to lie in the degree of organization of maintenance work and the kind of facilities present to carry it out. In other words, the results are a measure of the kind of thinking that is given to maintenance needs by those who have the ability and experience to work out the practical applications.

In this issue, therefore, we have assembled articles that represent the backbone of maintenance thinking and in an analysis of maintenance procedure of seventy-four industrial works, a picture is presented of how this work is being handled and the attention devoted to it. This particular analysis deserves a great deal of study. It is the first complete report of its kind to be presented as far as we know and it will be improved and made better in each January issue of INDUSTRIAL ENGINEER hereafter.

If any of our readers spot particular points of interest on which they would like special or detailed information, the editors of INDUSTRIAL ENGINEER will welcome such requests. Investigations will be made along the lines suggested and the results presented in the issues of 1923.


EDITORIAL ROOMS
Questions Asked and Answered by Readers
Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.
Practical Pete
W. J. Higgins

Who Can Answer These?

Construction of Testing Transformer—I would like to know how to make a small transformer for testing purposes that will step up from 110 volts, 60 cycles to 550 and 1100 volts. Please give the size of wire for the primary and secondary and show by a diagram how to put on the windings and make the taps. Also give dimensions of the core and insulation that should be used.
Tyrone, Pa. H. L. F.

* * * *

What Makes a Safety Switch Safe?—When installing safety switches the user has in mind protection from fire and safety hazards. I would like to see published in INDUSTRIAL ENGINEER comments from both users and manufacturers of safety switches on what they consider the essential points in the construction and use of the enclosed type safety switch.
Detroit, Mich. J. H. R.

* * * *

Trouble With Brushes—I have a 200 kw. d.c. generator driven by a synchronous motor. The brushes groove badly but do not arc. They are staggered and the commutator has been slotted and turned. The brushes seem to show a hard spot and cut the copper. This machine has a varying load and operates at 1200 r.p.m. A remedy for this brush trouble will be appreciated.
Madrid, Iowa. F. M.

* * * *

Cutting Out Coils in D. C. Machines—In the August number on pages 386 and 387 I was interested in the drawings by A. C. Roe. In the four- and eight-pole armatures I have noticed that the slots and segments were an odd number, while in the six-pole armatures the slots and segments are an even number. Will someone explain whether or not it makes any difference if the slots and segments are even or odd in both lap and wave windings when cutting out coils?
Richmond, Va. R. E. L. R.

* * * *

Expansion and Contraction of Steel Trolley Bar—What allowance must be made for expansion and contraction, due to changes in summer and winter temperatures, of a steel trolley bar 625 ft. long on an outside crane runway? This will be a (10 point carbon composition) rod 0.342 in. in diameter with supports 10 ft. apart. What is the best method of anchoring this rod to allow for this expansion?
Gary, Ind. A. L. G.

* * * *

Reconnecting Motors for Half Speed.—We have two 7½-hp., 60-cycle, 220-volt motors operating at 1800 r.p.m. These motors are connected in two-parallel delta. They have 40 slots with 4 coils in a group. Is it possible to reconnect the winding for a speed of 900 r.p.m. and get as good performance from the motors as when they were connected for 1800 r.p.m.?
Medina, O. C. F. N.

* * * *

Why Does This Motor Reverse?—What would cause a 2-hp., d.c. compound motor, when a heavy load is thrown on, to reverse its direction of rotation? It can be started in one direction and then stopped and the next time it is started it may run in the opposite direction.
Toronto, Canada. J. H. M.

Answers Received To Questions Asked

Heat Resisting and Insulating Cement.—I have been referred to the INDUSTRIAL ENGINEER by the A & M College of Texas for a good type of heat resisting and insulating cement and also a kind of insulation that will take the place of porcelain. We desire an insulating material that can be shaped, drilled when necessary and will stand heat if exposed to fire. Any information you can furnish will be appreciated.
Bartlett, Tex. A. C. H.

In answer to the question by A. C. H. of Bartlett, Texas, as to a heat resisting insulation which can be drilled and shaped, I would recommend Bakelite. It can be used for dipping or in its hard form it can be shaped, drilled, turned and tapped. The hard form can be bought in sheets or plates like fiber, tubes, rods, etc., and specially molded. It is fire and water proof and a very good insulator. Bakelite can be bought from the manufacturer in liquid form, or hard form, and it stands heat like mica and will not soften. It is made by the General Bakelite Company, New York City.
Chicago, Ill. CARL STEINIGER.

* * * *

In answer to A. C. H., whose inquiry was published in the November issue, we have found liquid glass ($Na_2 Si_4 O_9$) to be a good heat resisting insulating cement for many purposes. When mixed with soapstone powder it makes a good insulator. It may be mixed up to any consistency from paint to plaster, and will air dry or may be baked. A brick made of it may be machined or drilled. Try it for covering a resistance or heater coil wound on an asbestos tube, or for repairing.
Lead, S. Dak. R. F. CRAWFORD.

* * * *

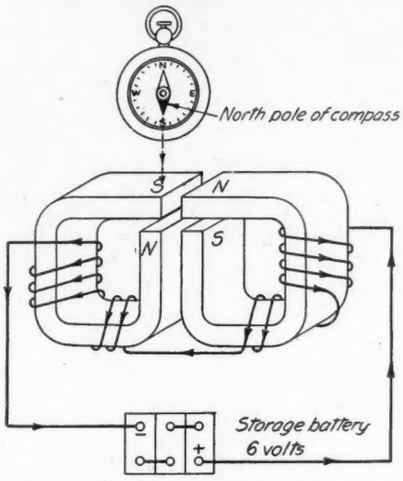
In regard to the inquiry in INDUSTRIAL ENGINEER by A. C. H., concerning heat resisting and insulating cement, I would refer him to D. M. Stewart Manufacturing Co., Chattanooga, Tenn., manufacturers of "Lavite," which I think would answer the purpose. The American Lava Corporation, 1419 William St., Chattanooga, Tenn., is also engaged in the same line.
Chief Engineer, PHILIP N. EMIGH.
Mountain Water Supply Co.,
Indian Creek, Pa.

* * * *

Remagnetizing Magnets.—Please show a good method for remagnetizing magnets such as used in magnetos and kilowatt-hour meters.
Dixon, Ill. G. L. H.

When the permanent magnets of a watthour meter become weak through accidental short-circuit or lightning stroke, it is very easy to remagnetize them by removing them

from the meter, wrapping with a short piece of heavy flexible wire as shown in the accompanying illustration and making several short-circuits on a well-charged auto-



Proper direction of current flow for remagnetizing magnets.

starting storage battery. These "shorts" should only be a fraction of a second in duration or the wire will become hot; and the actual time required by the current to do the magnetizing is almost inappreciable. It is advisable to get the polarity correct. This can be best accomplished with a compass, using the right-hand rule for current flow and magnetism. The accompanying sketch will show the relation between direction of current and magnetic polarity.

If a good battery is not available, connect to a d. c. generator of at least 50 kva. capacity in series with a single pole knife switch and about a 30-amp. fuse. Close the switch quickly, thus making a "dead" short and blowing the fuse. It is advisable to make 2 or 3 "shorts" to insure saturation of the iron.

The magnet may also be magnetized by blowing a fuse on a 25-cycle circuit, but although the fuse always blows on the peak of the wave, the polarity will be unknown and only one "short" should be made.

The magnet is now fully saturated and should be artificially aged to insure permanence. This is done by passing about 100 amp.-turns of 60 or 25 cycles around the magnet. For instance, if we have 10 turns per magnet, then pass 10 amps. Eight turns, pass 12 amps., etc. This must be passed by building the current from a low value to its maximum by means of an adjustable liquid, carbon, wire slide or reactive resistor. Let the current stay at its maximum for about 2 minutes, gently tapping the magnet with a brass rod if desired, and then decrease the current gradually. The circuit must not be broken quickly on a. c. current.

If after replacing the magnet on the meter it is too strong to allow adjustment, it may be removed and aged with 150 or 200 amp.-turns a. c. until it has the proper strength.

Aging may also be accomplished by using a coil of wire about 6 inches in diameter, wound with 1,200 or 1,100 turns of about No. 24 B. & S. copper. Connect this coil to a 110-volt, 60-cycle circuit and hold it about 5 or 6 inches from the magnets, the exact distance depending on experiment, to determine how much demagnetizing is required.

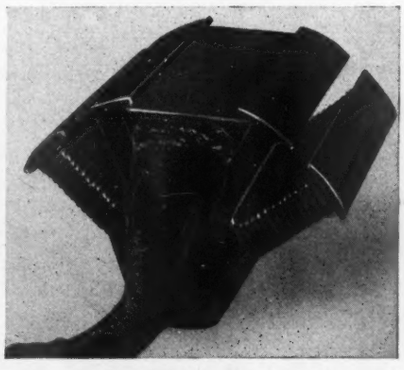
Summit, N. J. VICTOR H. TODD.

* * * *

Device for Testing Windings of Small Motors. — Will someone be good enough to describe a small testing transformer or similar device such as described on page 45 of the January issue of INDUSTRIAL ENGINEER, that can be used for testing the windings of fractional horsepower motors for short-circuits, grounds, open circuits, and the like?

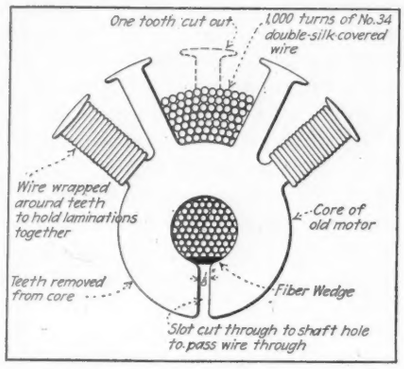
Nanty-Glo, Pa. S. J. S.

Regarding the request of S. J. S. for a simple test to locate grounds and short circuits in small stators, the following will describe a testing outfit for use on 110 volts, 60 cycles, which we made in the shop. We removed the shaft from an old d. c. fan motor armature and cut off the teeth as shown in the accompanying sketch. A slot was then cut in one side to allow the wires of the winding to be inserted in the hole formerly occupied by the shaft. A thousand turns of No. 34 double-silk-covered wire were wound on. After the winding was put in, wedges were inserted to hold it in place. Lamp-cord leads were fastened to the growler and taped.



Growler used to locate grounds and shorts in small stators.

To test for shorts, this small growler is placed on the stator teeth and a tin feeler is used across the slots, one coil pitch in advance of the growler. If the tin vibrates there


One tooth cut out
1000 turns of No.34 double-silk covered wire
Wire wrapped around teeth to hold laminations together
Core of old motor
Teeth removed from core
Fiber Wedge
Slot cut through to shaft hole to pass wire through

Details of construction of small growler.

is a short in that slot. To test for grounds, place the growler on the core and then touch one lead of the stator winding to the iron core. If a spark is produced, the winding is grounded. This test can be made after a stator is rewound and before connecting it up. Try each coil in the starting and running winding. The slot the ground is in can be located by making a good steady contact with one lead of the grounded coil to the stator core; then apply the growler and use the tin feeler to bridge the slots until it vibrates.

Detroit, Mich. A. C. ROE.

* * * *

Small Condenser for 110-Volt A. C. Circuit.—I want to make some experiments with condensers on a. c. circuits of 110 volts, the capacity of the condensers to be approximately one microfarad. 1. Where can I obtain the necessary sheets of tin foil? 2. What should I use for the dielectric? 3. Where can I obtain same? 4. What thickness should the dielectric be for 110 volts a. c.? I have never seen any of this material advertised, consequently this request to you.

Logansport, Ind. L. E. G.

If you desire only a small number of condensers of 1 m.f. capacity, it would undoubtedly be best to purchase them from some electrical store, or, if you are not able to do this, I would suggest getting a telephone condenser through your telephone exchange. A 1 m.f. condenser should not cost over $1.50 or $2, which would be much less than you could make the condenser for.

In making such a condenser aluminum foil is usually used at the present time and can be obtained from the Aluminum Company of America, which has offices in all large cities.

The thinnest foil made by this company, which measures about ½ mil in thickness, is the foil used. The dielectric is paper and the thickness of this paper runs from ½ to ¾ mil. This paper is very difficult to get, as it has to be purchased under specifications as to freedom from pin holes and conducting particles. Good specifications limit these conducting particles to sixty per square foot. If you intend to make your condenser of sheets stacked by hand probably the best paper that you could get would be a good grade of closely woven toilet paper of the thinnest tissue possible. This, I understand, is the thinnest commercial paper made. About two sheets of this paper should be sufficient for 110 volts. It would require about 18 sq. ft. of foil for 1 m.f. capacity when spaced with two sheets of ½-mil paper. After the condenser is formed it should be impregnated with paraffin under a vacuum.

L. J. MERRILL.
National Electric Condenser Co.,
Philadelphia, Pa.

* * * *

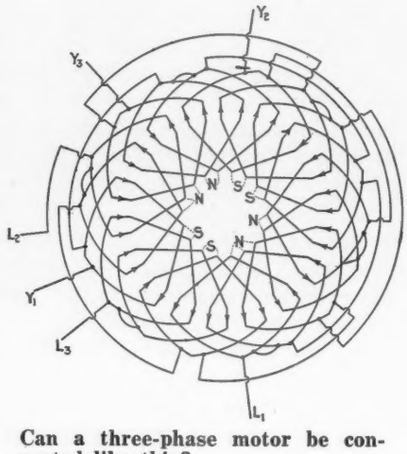
Changing Single-Phase Motor to Three-Phase.—I wish to change a Wagner motor over from single-phase to three-phase. What will be the requirements? Should I short-circuit the commutator? Will there then be enough copper in the rotor? I shall have to change the stator and distribute the winding from four concentrated poles to four or six distributed poles. Should I use the same length and gage of wire to do this or should I figure on more wire and a smaller size? The motor has No. 12 or No. 13 in the fields now.
Ardmore, Okla. R. W. MCMURRAY.

The stator winding will have to be redesigned for three-phase operation. The method outlined in A. M. Dudley's book, "Connecting Induction Motors," could be used. Regarding the rotor, after the stator has been rewound for three phase, the commutator on the rotor could be shorted and the motor tried out under load conditions to see if the present rotor winding will develop enough starting torque to start its load. If O. K., the brush rigging and centrifugal device can be removed and the commutator permanently shorted by burring over the commutator bars.

If more starting torque is required the rotor can be rewound with 10 per cent more turns and smaller size wire. Remove the commutator completely and connect the beginning and ending of each coil together, i. e., short circuit each.

Detroit, Mich. A. C. ROE.

Is This Motor Connection Correct?—I should like to know if the accompanying diagram of a motor winding is correct. This is for a three-phase, four-pole, 60-cycle, 36-slot motor with an 18-coil basket winding. If this connection is not correct I should like to see the right one published.
St. Anne de Beaupre, Quebec, Canada. E. L.



Can a three-phase motor be connected like this?

The accompanying sketch shows the connections for coils to permit proper operation of the motor referred to by E. L., St. Anne de Beaupre, Quebec, Canada. The numbers in the wiring diagrams, 1 and 2, indicate in the first case one coil-per-group-per-phase and in the second case, two coils-per-group-per-phase. The two coils, of course, are connected in series.

The arrows in the diagram indicate the direction of current in the coils at any one moment. When checking a three-phase circuit it is convenient to imagine that the current flows in the same direction in two legs of the circuit and in the opposite direction in the third leg. In applying this scheme to a motor diagram such as shown it is necessary to assume that the current flows in all three leads of the star connection toward the point of the star connection. In the case of a delta connection, that the current flows around the three sides of the delta in the same direction.

In using this diagram, therefore, the repair man need only lay out the required number of pole-phase groups and then draw arrows alternating the direction of their heads and draw in the jumper connections so that the instantaneous direction of current corresponds with the arrows. This arrangement will make it sure that the leads of the three phases of a motor are brought out to an electrical angle of 120 deg apart. This is usually a separation of two poles.

The method of drawing these diagrams is fully explained in "Armature Winding and Motor Repair," by D. H. Braymer, pages 52, 53 and 236. The applications of the diagrams are fully explained on pages

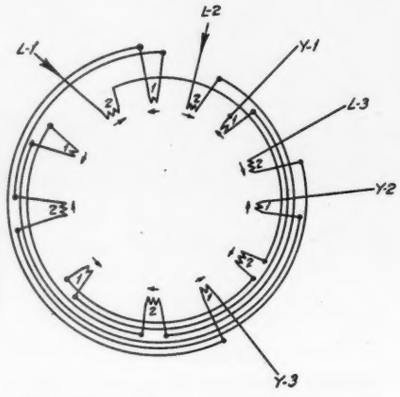


Diagram showing connection of pole-phase groups for motor question asked by E. L.

261 to 300 with many diagrams for motors of different poles and types of connection.

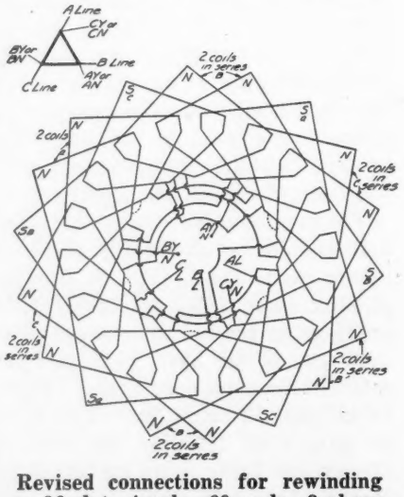
Richmond, Cal. U. O. MEISNER.

* * * *

The diagram of stator winding for the 3-phase motor shown by E. L. of St. Anne de Beaupre, Quebec, Canada, is not correct. In the accompanying drawing I have sketched the winding connections that can be used for winding this motor as a 4-pole, single-circuit Y with 18 coils and 36 slots.

In this diagram six coils per phase are used with a combination of one and two coils per pole and one coil per slot.

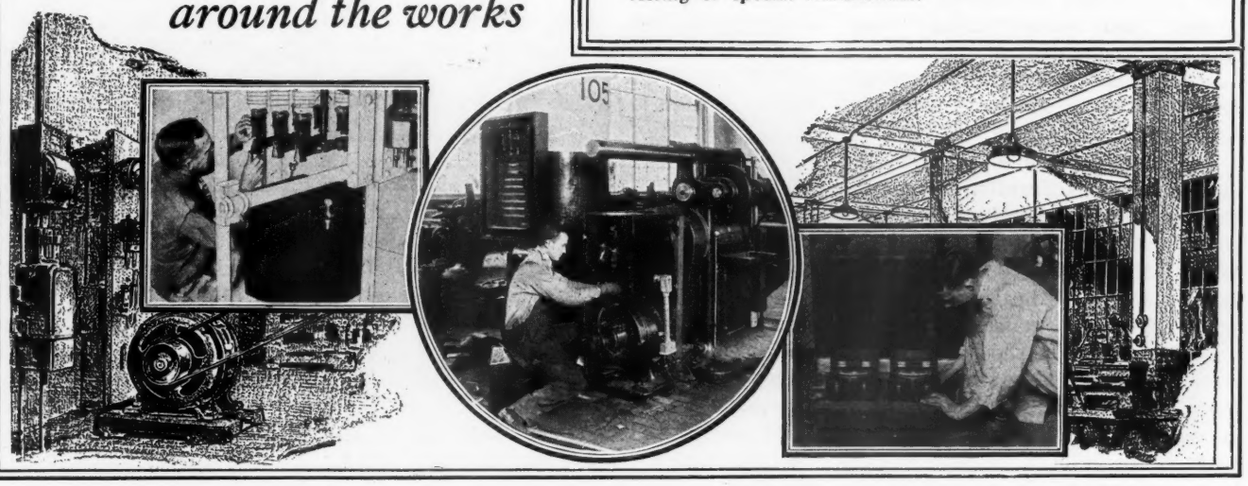
Allentown, Pa. CARL W. HEIMBACH.



Revised connections for rewinding a 36-slot, 4-pole, 60-cycle, 3-phase motor.

SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Lighting Up of Signal Lamp Indicates When Pump Accidentally Stops

A DEVICE which gives a signal when the circulating water ceases to flow to an internal-combustion engine, is in use in a plant in St. Louis, Mo.

The water for cooling the cylinders of this 300-hp. engine is obtained from a driven well. The supply being limited, it was necessary to install a cooling tower so the same water may be used continuously. The water is circulated through the cylinder jackets of the engine by means of a motor-driven centrifugal pump. The pump takes its suction through a pipe which descends vertically from the sump beneath the cooling tower and sends its discharge through the jackets and thence to the top of the tower.

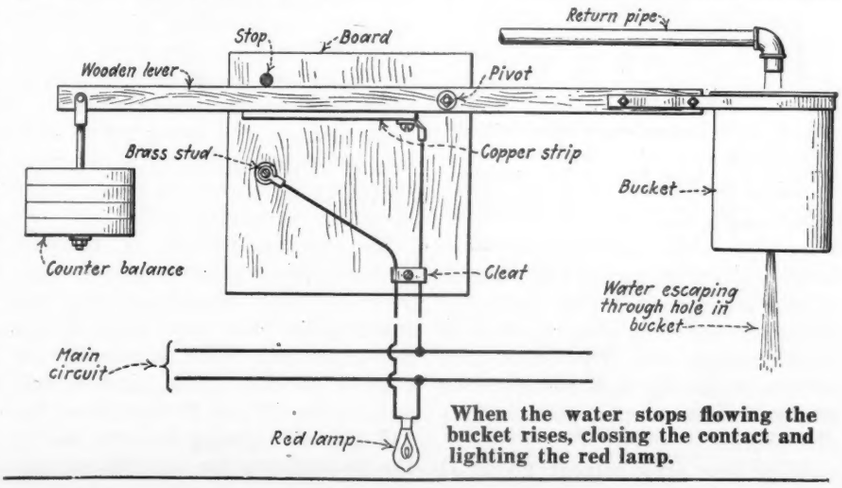
One day the circulating pump stopped, due to the blowing of a fuse in the motor circuit, and before the attendant became aware of the stoppage the engine also had dropped out. To prevent a repetition of the trouble the attendant determined to make a device that would give him immediate notice of stoppage of the jacket-water circulation. After considering various schemes he finally hit upon the idea shown in the sketch.

A wooden lever, about 5 ft. long, is pivoted at its middle point on a stud projecting from a board which is secured in an upright position at the top of the tower. A piece of strap iron, bent into a ring for holding a galvanized-iron bucket of about 1-gal. capacity, is bolted to one end of the lever. A set of counterbalance weights are hung from the other end. The bucket, which is hung directly beneath the outlet of the pipe which returns the water to the tower, has a ⅜-in. hole in its bottom. When the circulating pump is running, the returning water overflows the bucket.

When the circulation is just right the weight of the water in the bucket is counterbalanced by the weight hung on the opposite end of the lever. The lever then stands horizontally. But if the circulation ceases from any cause, the water runs out of the bucket through the hole in the bottom. The weighted end of the lever then falls and the copper strip, which is secured to the lower edge of the lever, makes contact with the brass stud, thus closing the circuit through a red lamp which is located conspicuously in the engine room.

A galvanized-iron shelter is built over this device to protect it from the elements and from the spray blown from the tower as the arm might freeze solid. A. J. DIXON.

St. Louis, Mo.



When the water stops flowing the bucket rises, closing the contact and lighting the red lamp.

Drying Out Motors Which Have Stood in Damp Location

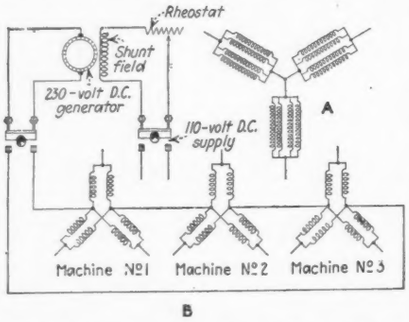
IF AN electrical machine has been standing idle for some time and exposed to much moisture, it should be dried out before going into service. Often it is difficult to get the right voltage, and so forth, for drying by passing current through the windings. A case of this kind which needed some ingenuity to work out the right method was recently handled by the writer.

This was in connection with drying three 440-volt, 275-amp., 250-hp., three-phase, 60-cycle synchronous motors direct-connected to compressors in an industrial plant in New

York City. After these motors were erected and before they were ready to be operated they were subjected to severe conditions of moisture, so that it was not considered safe to operate them without drying them out. An examination of the winding disclosed that it was a four-circuit star winding as shown in *A* of the accompanying drawing.

The only available current for drying out was from a compound-wound, 230-volt, direct-current generator with a rating of 230 amp. In order to be able to use this current and obtain good heating effect on the windings it was necessary to place as much of the windings in series as possible, with the minimum amount of work. This was done by taking any two of the four star points in each phase and putting the current in at one of the star points and out at the other, as shown at *B*. By connecting the three machines in series a voltage of approximately 65 volts and an amperage of 250 amp. was required to maintain a temperature of 185 deg. F., which was very satisfactory. By maintaining this temperature for thirty hours the motors were thoroughly dried out. To obtain this voltage and current the series winding of the generator was disconnected and the shunt field separately excited from a 110-volt direct-current service.

It will be noted that with the connection shown current is flowing through only half of the windings



How three motors were dried out at one time.

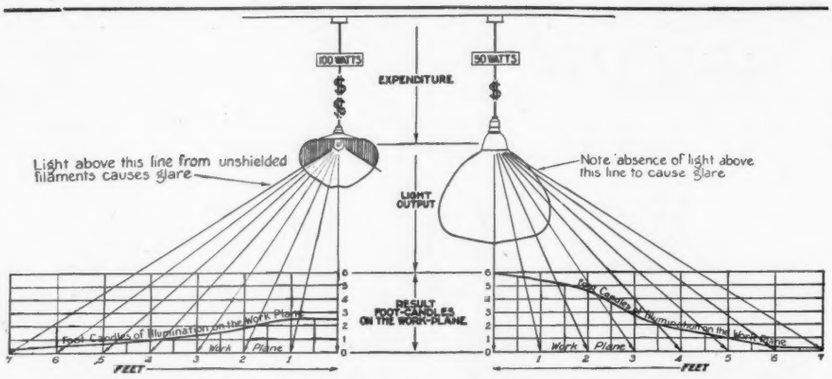
The motors were four-parallel, star-connected as shown at *A*. Current was passed through only two of the four circuits in each phase as shown at *B*.

of each machine, but as the winding is evenly distributed over the stator the whole winding soon reaches an even temperature. The entire time of disconnecting and reconnecting the three motors was approximately six hours.

With this arrangement about 11 volts were impressed on each section of the winding or 4.3 per cent of operating voltage. The current was (250÷3) or 83 1/3 amp. through each section or 120 per cent of rated current.

Of course if this percentage of current had been passed through all of the coils on the machine instead of half of them, the temperature would have been higher. In such a case the current would have to be less, say, only about 100 per cent, in each section to give a temperature satisfactory for drying. With rated current the heating would be above normal because the ventilation would be much less when the machine is standing still.

Newark, N. J. E. C. SOARES.


100 WATTS
EXPENDITURE
50 WATTS
Light above this line from unshielded filaments causes glare
Note absence of light above this line to cause glare
LIGHT OUTPUT
RESULT FOOT-CANDLES ON THE WORK-PLANE
Foot Candles of Illumination on the Work Plane
Work Plane
FEET

This diagram shows how better lighting at less cost can be secured by a correct use of lamp and reflector.

The illustration at the right indicates the increase in actual foot-candles of light on the work by the use of a deep-bowl, porcelain-enameled reflector containing a rugged 50-watt mill-type lamp over the light obtained from a 32-cp., 100-watt carbon lamp in a 10-in. flat cone reflector. The saving in energy is also apparent from the sizes of the lamps.

Importance of Rugged Lamps and Proper Reflectors Localized in Mill Lighting

RECENTLY INDUSTRIAL ENGINEER has described a number of ingenious methods for mounting lamps and reflectors in steel mills and in other places where there is considerable vibration. Unfortunately, the desire for a rugged light source not infrequently leads to the recommendation and use of a lamp and reflector combination which is not only uneconomical, but actually harmful because of the glare resulting from an insufficient shielding angle. In the past many mills have used, and are still using, 32-cp. carbon lamps, equipped with flat cone reflectors wherever so-called local lamps are required.

Rugged Lamps.—It is believed that a number of maintenance engineers and plant electricians have not investigated the new type Mazda mill-type lamp built especially for rugged service. The lamp—available only in the 25 and 50-watt sizes for 110-125-volt lighting circuits, and in the 50-watt size for 220-250-volt circuits—because of its low wattage, is best adapted for use on extension cords and local lighting devices which are used to furnish illumination only over a restricted area or for a machine.

The filament of this lamp is coiled and is mounted on a short, sturdy support. It is inherently rugged because of the special ring-type construction.

The lamp bulbs are of a short, sturdy construction and are tipless—a feature which is very important for extension cord and local lighting service, where the lamps are handled to a considerable extent. It must be remembered, however, that the ruggedness of mill-type lamps is obtained at a slight sacrifice of lamp efficiency and that lamps of the regular construction should be used wherever the conditions of service do not cause an excessive breakage.

Expenditure.—The 50-watt Mazda mill-type lamps are rated at 420 lumens. This is 27 per cent more light than is given by the 32-cp. carbon lamps, which require twice the expenditure of wattage. The 30 cents spent for a 32-cp. carbon lamp is of minor importance if it eats up $4 worth of 4-cent current to keep it burning for 1,000 hours. The more economical lamp in the long run is the mill-type lamp, which costs 10 cents more but consumes only $2 worth of current in the same time—and supplies twice the light on the work when used in the proper reflector.

Reflector Efficiency — Light and Foot-Candles.—It is important, in the first place, to use a lamp which produces a relatively large amount of light from the energy it consumes and, in the second place, to use a reflecting device which will permit the light so obtained to be fully utilized. The accompanying diagram shows that it is possible to obtain more actual foot-candles of light on the work by the use of a deep-bowl porcelain-enameled reflector containing a rugged 50-watt Mazda mill-type lamp, than can be obtained from the 32-cp., 100-watt carbon lamp in the 10-in. flat cone. The former, the deep bowl, is scientifically designed to direct the light to the work where it is needed, while the flat cone merely serves in a small way as a substitute for a bit of flat ceiling above the lamp. The effective distribution of light shown for the deep-bowl reflector and the 50-watt Mazda mill-type lamp is obtained by using the standard 7½-in. deep bowl designed for use with the standard 50-watt vacuum lamps, fitted with a standard 1⅜-in. socket extension plug to bring the filament of the mill-type lamp into proper position in the reflector. With the filament of the mill-type lamp in this position, the distribution of light and the reflector efficiency are approximately the same as are obtained when a regular vacuum 50-watt lamp is used without the socket extension. Reflector manufacturers design their equipment for a definite filament position and the user who disregards this fact fails to get the best results from his lighting.

Glare.—To the disadvantage of low efficiency characteristic of the carbon lamp and flat tin-cone shade must be added the handicap of glare, which is very evident because of the improper shielding angle. With the reflectors in the position shown in the diagram, for example, 4 ft. above the bed of a lathe used for trimming rolls, practically all of the light emitted in the angles above the 60-deg. line, indicated by the shaded portion in the distribution curve, will cause glare because the light comes directly into the worker's eyes from the unshielded filament. At all times light in the direction of the eye should be diffused. A 32-cp. carbon lamp in a flat tin-cone reflector at the height shown would be prohibited by a number of recent state lighting codes because of the glare.

To sum up: (1) Ruggedness can be obtained by using the recently standardized Mazda mill-type lamps; (2) the greatest utilization, or foot-candles of light on the work, is obtained by using properly designed reflectors in connection with the lamp; (3) mill-type lamps, having a short light-center-length, can be efficiently used in any reflector properly designed for regular 50-watt vacuum lamps by using a standard 1⅜-in. socket extension; (4) harmful glare is easily minimized by using reflectors with a sufficient shielding angle. JAMES M. KETCH.

Engineering Department,
National Lamp Works of G. E. Co.,
Cleveland, Ohio.

Automatically Stopping First of Two Motors When Second Stops

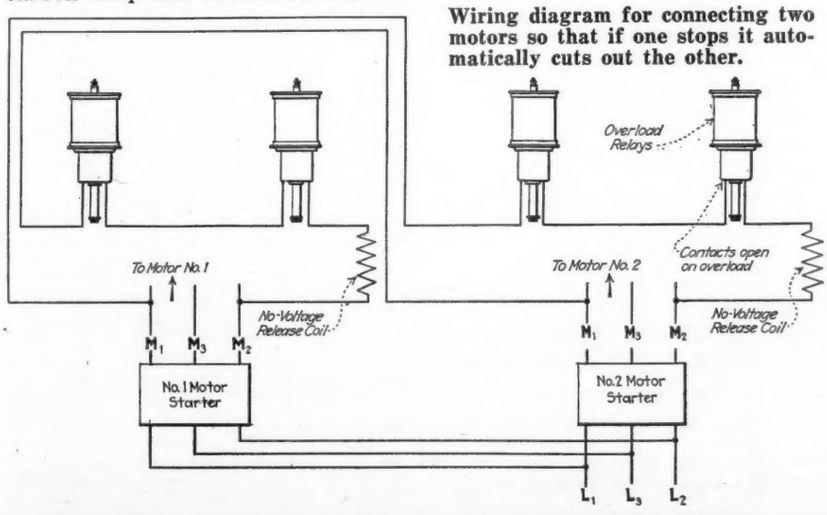
WHEN one machine feeds another considerable trouble is likely to result unless some provision is made to stop the first automatically in case the second should get out of order and stop. For example, an ice crusher and a conveyor operated in combination often went out of commission because the conveyor would for some reason become choked and the overload relays stop its motor. Unless stopped in time, the crusher would continue to fill the conveyor pit until the lower end of the chain and buckets was practically in a solid cake of ice. A new man would invariably fail to open the crusher switch soon enough to prevent this. His next move would be to throw in the switch of the conveyor which usually resulted in broken chains and buckets bent out of shape or torn off, or if we were lucky, only the chains off the sprocket. In any case it gave a mean job for repairs.

To overcome this difficulty an idea was used which may be an old one with others, but was tried out at our plant for the first time. This plan was to connect the motors so that if one motor should stop the other would automatically stop also. The accompanying sketch shows how the connections were made. It must be remembered that this scheme is good only where both motors are always used together if overload and no-voltage protection is wanted for either or both motors as individual machines.

The starters used in this case were the Crocker-Wheeler AX starters with overload relays and no-voltage release coils. The sketch shows the no-volt release coil circuits, which alone are changed. VICTOR ORTH.

Gardenville, N. Y.

Wiring diagram for connecting two motors so that if one stops it automatically cuts out the other.

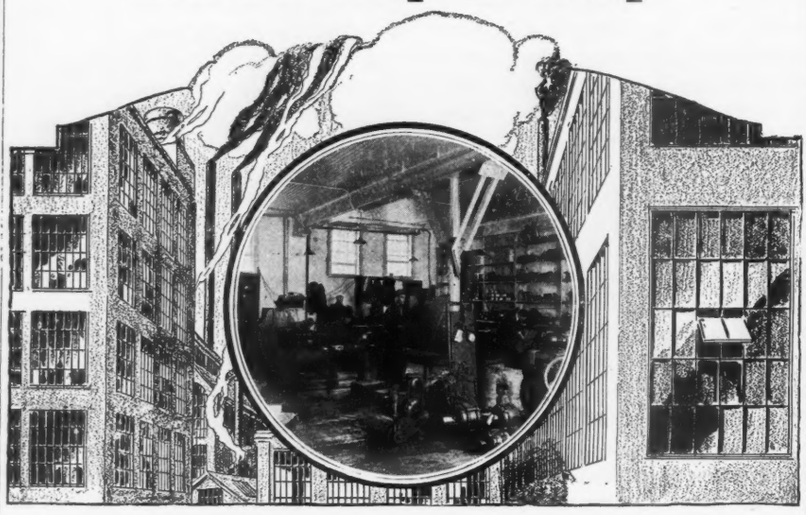


Choosing Proper Type Condulet When Wiring for Motor

IN THE August issue of INDUSTRIAL ENGINEER there is shown on page 368 a good and a bad example of wiring old-type motors. These motors have exposed terminals on both sides of the frame, which naturally renders it difficult to make an installation which is comparable in neatness and general appearance with installations of modern motors. In the good example mentioned above the illustration shows that two type A condulets were used. I do not wish to appear critical, but it seems to me that a type B or type E condulet would have been preferable in this case.

Topeka, Kan. C. DICKERSON.

In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welocme.

Heating of Induction Motor Due to Grounded Wedges

AN INDUCTION motor that ran very hot, although not fully loaded, came to the writer's attention some time ago. This was a 15-hp. motor which drove a pump in a chemical plant. It had replaced a 10-hp. motor which had carried the load satisfactorily without heating. When the 10-hp. motor broke down it was decided to put in the 15-hp. motor temporarily. This motor was a squirrel-cage machine rated at 15 hp., three phases, twenty-five cycles, four poles, 720 r.p.m., 40 deg. rise at constant duty. It was one of the company's spare motors and was being used for temporary service on an elevator, in intermittent duty, where it worked satisfactorily. But when it was connected to the pump it would run for only about three or four hours when it would become so hot that it had to be shut down. The motor was tested for grounds, shorted coils, loose bars, torque, speed, and so on, and found perfect but it would still heat up after a three-hour run.

This was a puzzle but finally investigation revealed the fact that the dust in the plant was a mixture of carbon and other conducting materials, and that a thick sticky layer was soon formed on any stationary object. Also, this motor had in the stator slots metal wedges of the two-piece type, i. e., iron hair pin and brass center pin, the wedge being insulated from the stator laminations by a 0.010-in. fishpaper cell. Upon testing these wedges it was found that every wedge was grounded. The dust formed a bridge over the insulation entirely across the slot, thus short circuiting the tooth laminations and forming a path for eddy currents. These eddy currents in the rotor caused the heating. This was borne out by the fact that on a test run, only the stator iron got hot while the winding remained cool. This trouble was not experienced when the motor was used for intermittent duty, as it was not in service long enough at one time for eddy currents to heat up the iron.

The manufacturers of the motor were then consulted and agreed to furnish a new type of metal wedge that had been developed which they said would clear the trouble and would still retain the advantages of a metal wedge.

The motor was sent in to the shop where it was thoroughly cleaned and the old wedges were removed. The new wedge resembled a fiber wedge in shape but was composed of micarta with iron wire imbedded in it. The micarta completely surrounded the iron so that there was no chance for grounding the wedges.

After the wedges were put in, the motor winding was given three dips in Sterling varnish and baked fourteen hours after each dip. Then it was sprayed with an air-dry varnish. When put into service the motor operated satisfactorily and has continued to do so up to the present time, over eighteen months.

Detroit, Mich. A. C. ROE.

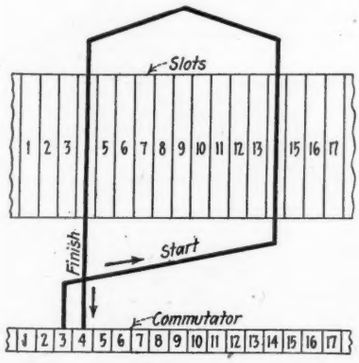
Data Which Should Be Taken Before Stripping a Motor

BEFORE stripping a motor that has to be rewound, certain information should always be put down on paper. No matter how familiar one may think he is with a motor before it is stripped, he may forget some important connection before the time when he has to reconnect it. Such a job is often held up while waiting for insulation, wire, coils, and so on, or some other more important job may require the attention of the repair man.

Card which holds complete information on a motor.

MOTOR NO. 16	LOCATION Wood Shop #1 Planer				
H. P. 40	TYPE M. S.		MFR. Westinghouse		
FORM Open	STYLE #151786		FRAME 334 A.		
PHASE 2	CYCLE 60		R.P.M. 860		
VOLTS 440	AMPS. 45.				
BEARINGS 2 Piece					
CONNECTION Belt Drive			CONDITION A.1.		
PURCHASED 1911	INST. 11 - (Word) 19				
WINDINGS Formed & Coils, Open Slots, Squirrel Cage rotor.					
SERIAL NO. 934059.					
STARTER Westinghouse Air Break			FUSE 75.		
TESTS 3/28/14	FROM		LOAD 3.2 HP.		
5/7/19	Variable		" 22 HP.		

Form F-940	DATE	REPAIRS	COST	CHANGED
	7/8/22	2 New Bearings	5 00	19 FROM East Line TO Planer



The drawings shown here are samples taken from an alternating-current and a direct-current motor. I usually make a rough chart on the order of these drawings, and then at my leisure draw a better one using colored ink for the different phases. I keep these charts in a loose-leaf ledger. Probably the most important point to bring out in a chart is whether the connection should be made from the front or the back of a coil. In addition to the drawings I write down data such as that listed in the caption underneath the drawings on this page.

When rewinding the motor if sufficient information is not contained on these drawings I consult the card index of all motors, which we keep in file. A copy of one of these cards is shown herewith. N. S. DAVIS.

Batavia, N. Y.

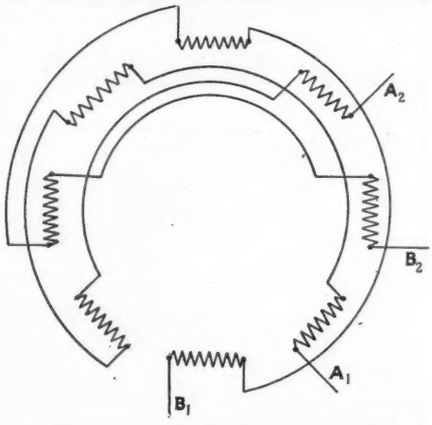
Composition of Hard-Drawn Rods Used for Arc-Welding

HARD drawn rod electrodes conforming to one or the other of the specifications shown in the table have been standardized by a leading industrial concern on the Pacific Coast. These rods are used on mild steel, structural shapes, plates, bars, low-carbon forgings, and castings. For arc-welding on high-carbon and alloy steels special electrodes are used. On high-carbon steels where the weld is not to be machined, but a hard wearing surface is the principal consideration, electrodes containing 0.95 per cent carbon are used. If the welds must possess unusual density and uniformity in order to secure a high polish or be easily worked, covered nickel-steel electrodes are recommended for use on high-carbon steel.

San Jose, Cal. D. N. LOUIS.

COMPOSITION OF HARD-DRAWN RODS FOR ARC-WELDING

	A Per Cent	B Per Cent
Carbon	not over 0.06	0.13-0.18
Manganese	not over 0.15	0.40-0.60
Phosphorus	not over 0.04	not over 0.04
Sulphur	not over 0.04	not over 0.04
Silicon	not over 0.08	not over 0.06



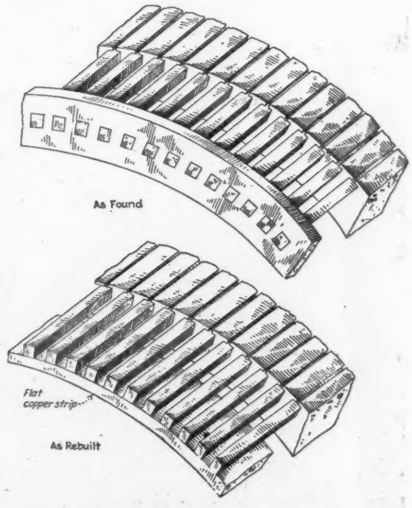
Diagrams drawn before stripping motors.

At the left is a drawing for a d.c. motor; at the right, one for an a.c. motor. In addition such information as the following should be recorded: For the a.c. motor—Westinghouse, 2 hp., two-phase, 60 cycle, 1700 r.p.m., twenty-four 68-turn coils, No. 18 d.c.c. wire, three coils to a pole, 1 coil to a slot, throw 1-and-10. For the d.c. motor—Sprague, 6 hp., 600 r.p.m., d.c., 240 volts, 26.7 amp., twenty-seven coils, thirty turns, No. 22 d.c.c.

Rebuilding Rotor End-Rings Reduces Trouble

MUCH of the trouble caused by induction-motor rotor bars becoming unsoldered from the end rings has been eliminated from the older motors of the Old Dominion Copper Company, by a change in the end-ring construction. Originally the end-ring construction was as shown in one of the illustrations. The bars projected through the end rings. When such motors are brought into the shop for repairs these end rings are removed and a copper band is soldered in place as shown underneath the bars. In some cases rivets are placed through the bars and ring to increase the mechanical strength. The ring consists of a flat copper strip, mitered and silver-soldered. STEPHEN TILLMAN.

Chief Electrician,
Old Dominion Copper Company,
Globe, Ariz.



The old end rings were removed and a copper band silver-soldered beneath the bars.

Low-Resistance End Ring Reduces Motor Speed

UPON renewing the bars and end rings of a 100-hp., 2,200-volt, three-phase motor at the works of the Union Pacific Coal Company, we found that the motor would not run above approximately half speed at no load. The motor ran hot and threw fire from the rotor. Examination showed that several rotor bars were broken at the end ring, so it was decided to renew the rotor bars and end ring as the only method of making a first-class repair job. The proper size of rectangular copper for the rotor bars was not available; so they were made from 4/0 round copper wire and hammered to size. Although the original end ring was of different shape and material, it was assumed that the resistance in both cases would be the same, but this could not be verified, owing to lack of proper facilities for making refined measurements. The bars were double riveted at each end and soldered and the work considered first class. Upon testing out the motor it was found to take excessive current with 1,500 volts applied at the terminals and finally damaged the auto-transformer coils in the starter. A starter capable of starting a 500-hp. motor was provided, but again the motor took excessive current and accelerated to only 900 r.p.m., instead of to 1,800 r.p.m., its rated speed. Applying the full rating of 2,200 volts failed to cause any increase in speed.

When the manufacturer was consulted it was learned that the end ring contained too much copper and we were advised to reduce the cross-section one-half. After this was done the motor came up to normal speed. The trouble was caused by the assumption that the resistance of a ¼ by 2-in. copper bar was the same as that of a 1-in. by 1-in. alloy ring.

D. C. MCKEEHAN.

Chief Electrician,
The Union Pacific Coal Co.,
Rock Springs, Wyo.

A Portable Outfit With Simple Grid Connections to Give Wide Range of Resistance

BY USE of single-pole, double-throw switches connected as shown in the accompanying diagram, a wide range of resistance is obtained in the portable and stationary resistance units employed in an Eastern industrial shop. The principle of this method of connecting is shown in Fig. 1, where *a*, *b*, *c*, and *d* are resistance units connected by single-pole, double-throw switches to either *e* or *f*. The maximum resistance obtainable is the sum of *a*, *b*, *c*, *d*, the current being limited to that allowable for one of the sections. To obtain this maximum resistance switch No. 1 is thrown over to *e*, switch No. 5 is thrown to *f*, and the other switches are left open. The minimum resistance will be one-quarter of the resistance of any section (provided they are all equal), and with this condition the maximum current will be four times the maximum current allowable for any one section. This condition is obtained by throwing switches 1, 3 and 5 to the left, 2 and 4 to the right. Various steps can be obtained between the maximum and minimum values.

Three resistance tables connected in this manner have been mounted on wheels, as shown at right, so that they can be conveniently moved from one place to another. Each of these tables is made up of twelve resistance sections, the resistance of each section being 0.5 ohm, 0.75 ohm and 1 ohm, and the carrying capacity of each section being 35 amp., 25 amp. and 15 amp., respectively, for the three cables.

A permanently mounted set of grids using the same method of connection has been made up to give a range of 2.5 amp. to 830 amp. at 230 volts. This method of switching is not confined to large resistances; it has been found very useful also in making up smaller rheostats. By mounting on wheels as shown, it can be used more conveniently in any part of the laboratory.

Newark, N. J. EUSTACE C. SOARES.

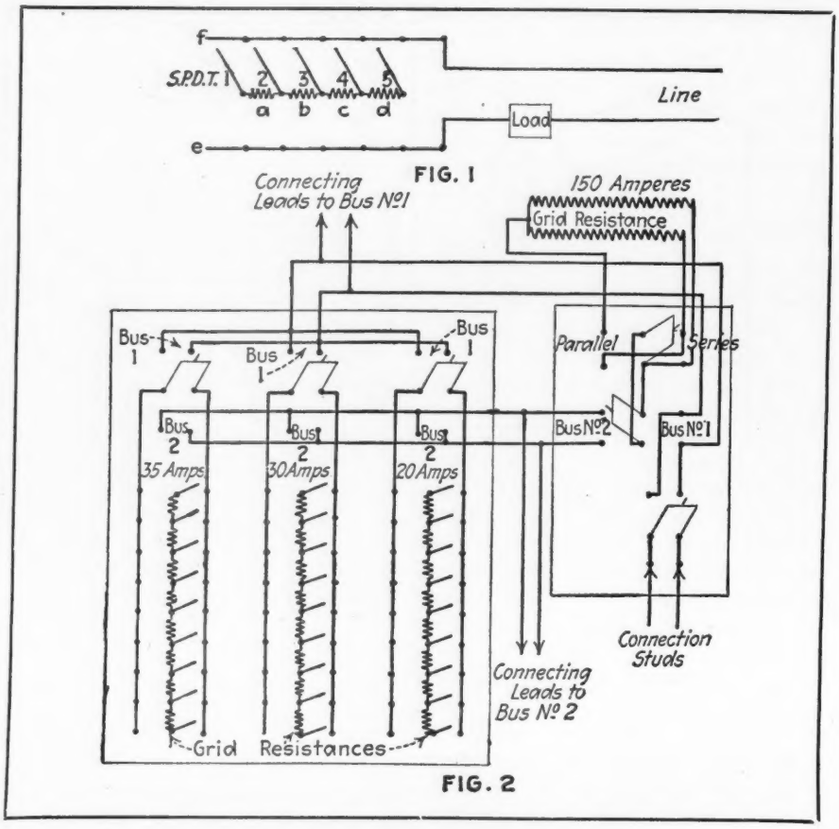
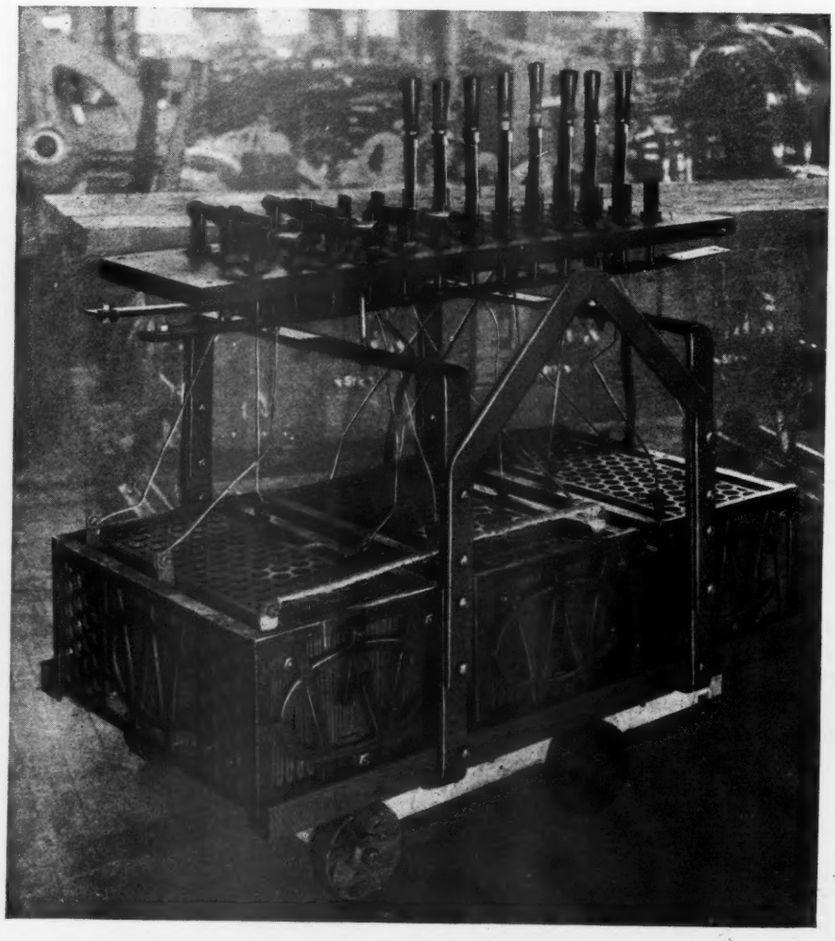


Fig. 1—Scheme of connections for obtaining a variable resistance for test work.

Fig. 2—Adjustable rheostats which give wide range of resistance for the number of resistance units employed.

This rheostat table may be rolled about the laboratory and in this way is made more convenient for general testing.



Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Robbing a Job of Its Disagreeable Features by Doing It Mechanically

ON JOBS which are disagreeable because of the conditions surrounding the work, such as paint or varnish dipping, cleaning and other similar tasks where the operator is likely to have paint or cleaning solution splashed on him, carriers have been installed to good advantage. How these disagreeable features of one paint-dipping job are eliminated is shown in the accompanying illustration. Here the parts to be dipped are hung on a special carrier riding on a double tramrail and carried to the dipping vats. By manipulating the two pear-shaped handles, a section of this tramrail is lowered until the parts are immersed in the paint. They are then raised by the motor operating this section of the elevator and pushed on to the right over the dripping section. The parts, still on this tramrail carrier, then go on to and through the drying ovens.

The parts are thus placed on the carrier before they are dipped and are not touched again until after they are dry, so that the men do not come in contact with the sticky paint. This equipment was manufactured and installed by the Cleveland Crane and Engineering Company, Wickliffe, Ohio.

The operator can perform a disagreeable task and still keep his hands clean.

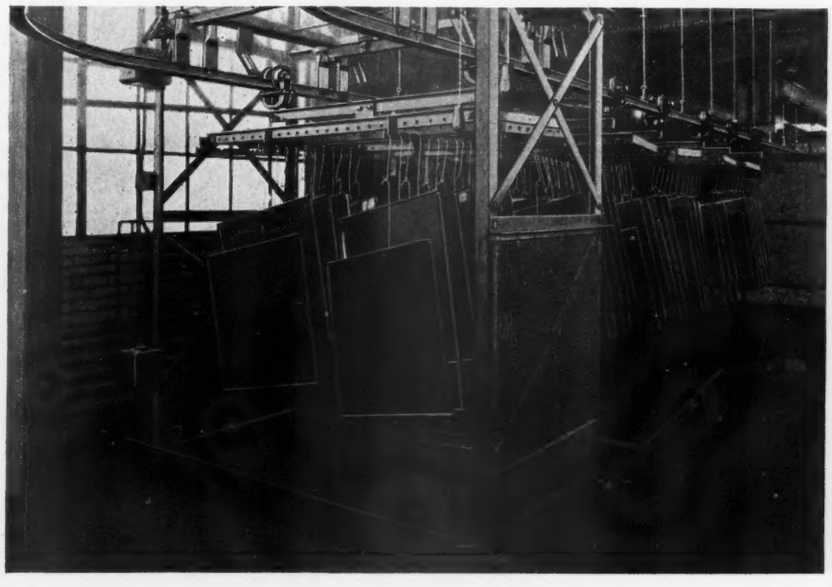
It is difficult to get men, when labor is scarce, to perform dipping jobs and other similar tasks where they are spotted with paint which ruins their clothes and gets onto their hands and faces and even into their hair. With equipment such as this, it is not necessary to touch the parts when they are wet.

Moving Hacksaw to Work Eliminates Double Handling of Heavy Steel Bars

SOMETIMES it is easier to bring the machine to the work than to take the work to the machine. This is a common practice with many small portable tools and with some large special machines. However, one would hardly expect that such a tool as the power hacksaw would be moved from job to job instead of taking the work to the machine. Nevertheless, this is actually done at the plant of The Louis Allis Company, Milwaukee, Wis.

Here a power hacksaw is mounted on the platform of a power-driven portable elevator or tiering machine made by the Economy Engineering Company, Chicago, Ill. The platform carrying the hacksaw can be raised or lowered as desired. This company previously removed heavy steel bars which were used for making the armature shafts from the stock racks, trucked them to the machine shop, cut them into desired lengths, returned these lengths and the uncut stock to the storeroom and made a record of the operation. Later, when the foreman in the armature department got an order for armatures those same shafts were removed and trucked to the armature department. This required a large amount of extra handling of heavy bars.

Since the hacksaw has been made portable, the procedure is: The foreman orders a definite number of pieces of shafting for armatures direct from the storeroom. The storeroom man elevates the hacksaw, on the portable-elevator platform, to the proper size of shafting, cuts the desired number of lengths, without removing the long length of shafting from the racks, and delivers them direct to the armature department. This eliminates the delay, annoyance and hard work of taking the stock to the saw in the machine shop and of returning the unused portion to the storeroom. On large bar stock the labor and time saved would be considerable. It also simplifies the stockroom book work necessary.



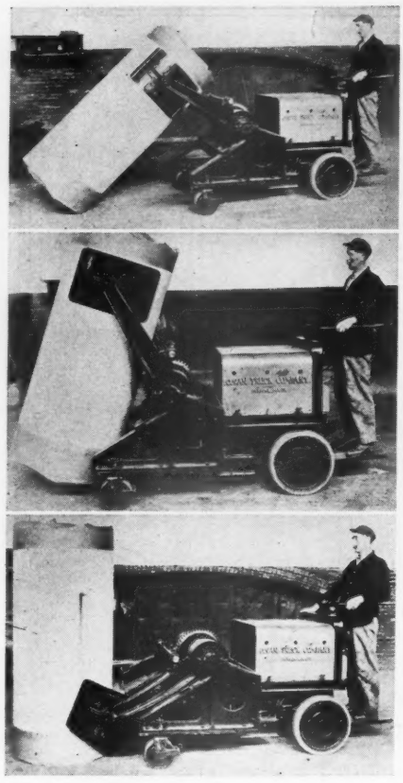
Saving $21,000 a Year With a Special Electric Truck For Handling Paper Rolls

ONE OF the principal features of material-handling equipment has been the design and construction of special machines for special purposes. One example of this is the special electric lift truck for handling rolls of paper as shown in the three accompanying illustrations. Several of these trucks are in use at the different plants of one large paper company. Before installing these trucks the large 72-in. rolls of paper were handled on a 24-hour-a-day basis by seven men per shift. These seven men were employed for finishing, up-ending and trucking. Of this gang five men were required to up-end the roll.

Since this truck has been adopted only two men and one truck are required per shift. Both men are finishers; one is engaged in finishing and driving the truck to the shipping department; the other in finishing and heading the roll. In this way an initial saving of five men per shift has been effected, which in dollars and cents, on a 300-day annual basis, amounts to over $21,000, or several times the original cost of the truck.

There is also a material saving in the time required to handle and carry the roll, to say nothing of having made it much easier on the men. The truck can be used for either lifting the roll from a horizontal position or from a vertical position. One of the distinctive features of the truck is the fact that when the lifting hands come together on the roll with sufficient pressure to lift it, the lifting mechanism automatically elevates the roll without exerting a crushing pressure. The speed adjustment of the truck is so regulated that the truck can be maneuvered up to a roll without breaking the edge of the roll while lifting.

The truck was installed by the Cowan Truck Company, Holyoke, Mass., and is equipped with General Electric motors, Exide batteries, Brown - Lipe - Chapin differential, Alemite system of lubrication throughout, and Cutler - Hammer controller.



Special electric storage battery truck for handling rolls of paper, which takes the place of 15 men.

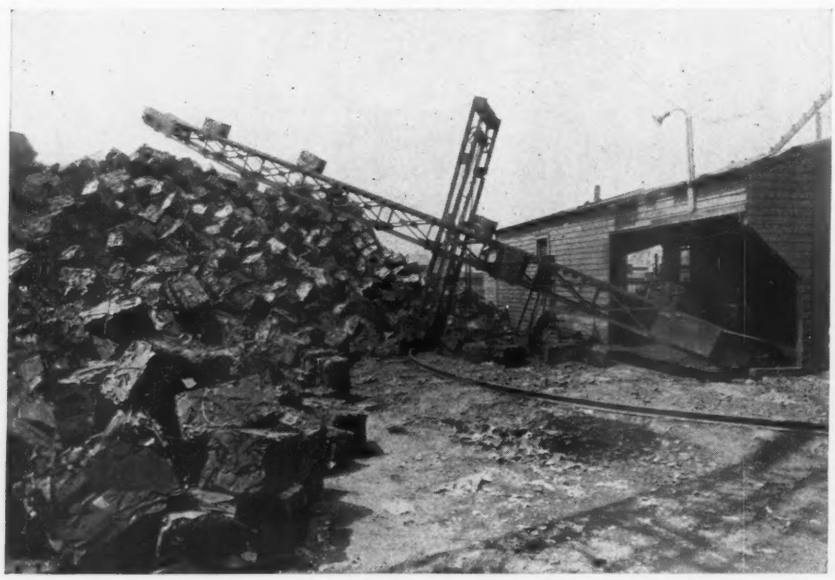
This truck will pick up a 72-in. roll of paper when it is lying down or standing up, carry it to its destination and stand it up or lay it down without damage to the roll. In one paper mill the installation of this truck saved over $21,000 a year by eliminating five men per shift in a plant operating three shifts per day.

How a Conveyor Reduces the Accident Hazard When Piling Rusty Scrap

THE SPECIAL piling conveyor, shown in the accompanying illustration, is used for piling the bales of scrap directly from the baling machine into the storage pile where they are later loaded into cars for shipment. These bales are not only heavy, but are dangerous to handle by hand due to the many sharp and often rusty edges. A conveyor of this type can pile them over a semi-circular area, due to the circular track upon which it is supported and travels.

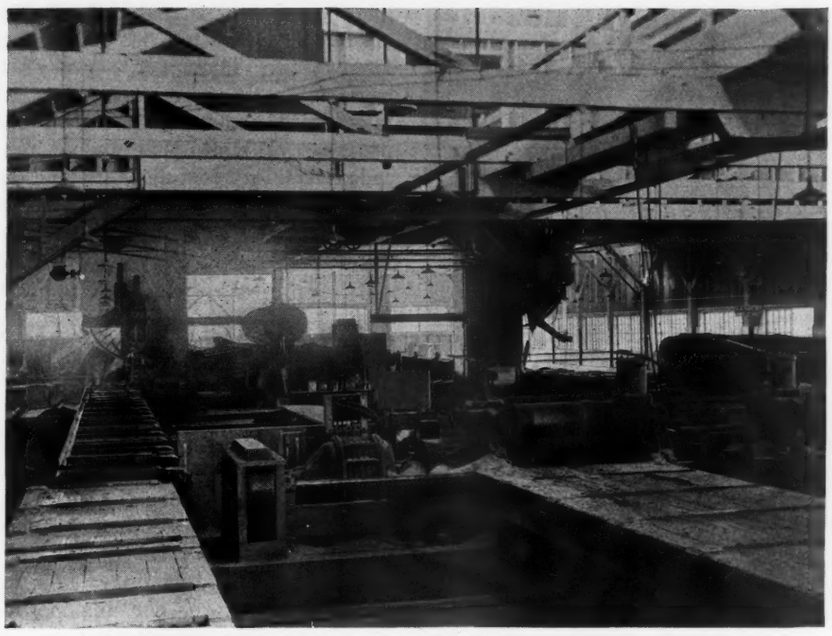
Many jobs similar to this are serious accident hazards. One of the best methods of making them safe is to do them mechanically. Men in gangs are a hazard to each other; if one man "lets go" of a heavy lift prematurely, the other men are liable to be hurt. However, the man operating a conveyor like this has only himself to look out for and so risks less chance of injury. One of the usual results from the installation of labor-saving equipment has been a decrease in number of accidents.

A similar type of conveyor is also used for unloading coal, sand and other loose materials. Gondola cars are dumped into a hopper feeding down into a conveyor of this type which discharges onto a circular pile in much the same way. This not only eliminates the large force of labor which would be required if it were done by man-power, but it also enables the coal or other material to be piled over a larger area and much higher than would be possible with wheelbarrows.



The accident hazard would be very great if men piled these bales of metal scrap. This conveyor is not affected by scratches from rusty metal.

Work like this is too heavy and hazardous and if men can get other jobs it is difficult to keep them on such tasks. Many other "back-breaking and thumb-smashing" jobs can be simplified as easily by mechanical methods and at the same time reduce the cost of the operation.



Sawdust and shavings make work for the maintenance department in lumber mills.
A motor-driven edger is shown in the left foreground of the illustration.

Maintenance Analysis

(*Continued from page* 51)

One sheet is thus sufficient for a month, or four inspections. If a motor and its control are found to be in perfect condition the inspector puts an O. K. opposite the motor number, in the proper date column. If the motor is defective in any way, the nature of the trouble is noted in the same manner. There is thus afforded a complete record of all inspections made, with the results.

In one of the large packing plants where a large number of motors are operated under very severe conditions, and the failure of a motor may occasion a good deal of loss and delay, a different plan is in force. The entire plant is divided into four sections and each section is put in charge of an inspector who is held strictly responsible for the continuous operation of the motors in his section. He is not required to make reports and is held to no definite routine, but can inspect a motor or other equipment three times a day or once a week, as he considers necessary. When a motor fails, a written report showing the cause of the failure must be given to the chief electrician. If the trouble was not due to neglect the inspector is absolved from all blame. If the failure was due to neglect or other preventable cause, which happens very rarely, the inspector is reprimanded or otherwise disciplined.

Although this method of handling inspection work may not be ideal in all respects it has, under proper supervision, worked out very successfully in this and a number of other plants where continuity of motor service is highly important. Perhaps one reason for this success is that it allows the inspector to use his judgment and initiative and put the emphasis on his work in the proper place, something that a hard-and-fast schedule may not permit. He can come closer to estimating the effects of natural wear and tear than anyone else in the works for, like the family doctor, he knows the ailments of his regular patients.

While it may not be necessary in all cases to have a written report of every inspection, when this shows that the equipment is in good condition, it is very essential that a complete record be kept of all defects and failures which develop, together with the nature and cost of the repairs. In too many instances the fact is overlooked that records such as these are the vital statistics of maintenance work. To attempt to carry it on without these records would be like trying to conduct a business without a set of books.

Records of Equipment Failures Should Be Carefully Studied and Analyzed

As Arthur J. Whitcomb pointed out on page 377 of the August issue of INDUSTRIAL ENGINEER, an analysis of the records of motor failures is of interest: First, to the motor inspector so that he may know what parts to watch closest; second, to the storekeeper in order that he may keep an adequate supply of the parts most frequently needed; third, to the electric repair shop so that there may be kept available facilities for the repair of motors or equipment on which failures occur most often, and fourth, to the electrical superintendent in order that he may have a grasp of the number and kinds of failures and may also be able to compare the failures of one period with those of another. Further, careful study and analysis of the records of failures will often disclose in the design or application of equipment inherent weaknesses which might otherwise pass unnoticed. For example, repeated failures of a motor or its control equipment means that something is wrong. These parts are either overloaded or are of the wrong type for the service requirements, or are being neglected. Finding the proper remedy may or may not be a simple matter; in any event, a weak spot has been pointed out.

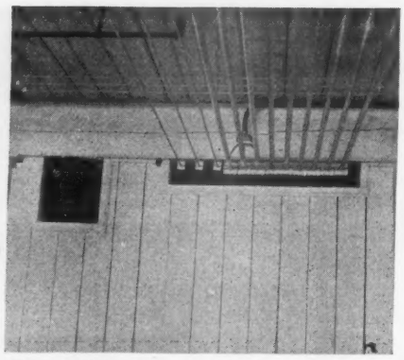
The value of accurate repair cost records, particularly the cost of making new coils, bearings and other parts, is often overlooked. The repair shop usually turns in a labor-and-material cost for at least the larger jobs, but there is frequently no definite data as to the cost of the coils and other parts which are made in the shop; therefore it is impossible to tell whether these can be bought from the manufacturer more cheaply than they can be made. Except as an emergency measure, when speed of repair is important, there is no economy in spending $10 to make a part which can be bought for $7.50. This is, however, done in many instances and increases the cost of repair work unduly. The only way this condition can be avoided is to find out exactly what it costs to make such parts and then compare these figures with the manufacturer's prices.

A repair shop operated in connection with the electrical department of an industrial works is just as much of a business enterprise as a commercial repair shop and the same business principles should be applied in its management. Guesswork or inaccurate records will cause loss in the one as surely as in the other.

The Engineer and Contractor

(*Continued from page* 22)

details of the specifications for the individual jobs would be essential to such a specific interpretation. These are submitted merely as examples of analyses that are useful and essential to the estimator who possesses a fundamental knowledge of trends in costs and the requirements of high standards of construction practice. These photographs illustrate some types of construction that present problems for experienced men and represent good practice from every standpoint. It is usually found advisable and profitable to make and file photographs showing stages of progress of the work. These are useful in connection with instructions to new superintendents and foremen employed by electrical contractors and as illustrations of methods of doing the work when changes or improved methods are to be followed. In such cases they serve to definitely picture the details of the work in the minds of superintendents and foremen and are available to them as references during the progress of the work as well as at the time they are being instructed in regard to it before it starts. Moreover, such a file of photographs serves as valuable silent evidence of the character and quality of workmanship that the electrical contractor is capable of furnishing. They also serve as a basis for settling controversies that may arise out of conflicts in the progress of work that should precede electrical installations and as the basis for extra costs when deviations from the specifications are being considered.



The finish on a job illustrated by these paneled openings is one of the things that add as much to class of workmanship as permanency of construction.

The lower illustration shows how daylight conditions shown in the upper illustration can be approached by good illumination. Cooper-Hewitt lights are used.

Maintenance Work Can be Audited

(*Continued from page* 15)

He has endeavored to explain and give reasons why the electrical storeroom should be under the electrical superintendent, how the electrical storekeeper keeps track of his stock by a perpetual inventory, how he knows when to reorder, his method of giving this information to the electrical superintendent who either approves or disapproves the requisition and thus releases the electrical storekeeper's responsibility in not having the material. Also it is shown how the "Main Storeroom" is enabled to keep a check on the material being requisitioned, how the need for the material is brought to the attention of the general superintendent, the operating vice-president and finally the purchasing agent, who at once orders the material from the manufacturer. So far during the cycle, the inventory card has shown the electrical storekeeper the need for the material and the requisition has rendered an accounting of this need to the electrical superintendent, the main storekeeper, the general superintendent, the operating vice-president and the purchasing agent. The material as received at the "Main Storehouse" and the "Memorandum of Receipts" forms the audit or accounting of this material until it has reached the electrical storeroom and it forms the voucher, after the OK of the electrical storekeeper, to the accounting department so that they may pass the invoices for payment. After the material is used, the "Storehouse Order" forms the means of accounting for why and where the material was used and is the authority for the electrical storekeeper to charge the material off his ledger or inventory card, and likewise for the main storekeeper to charge the value of material used against departments using it. Thus the cycle of purchase and use of materials is finished.

Maintenance and Operation Bonus

(*Continued from page* 10)

of all other motors in the plant which may be substituted for it. Thus, whenever a breakdown occurs, even though no substitute is in the store room, it is generally possible to pick out a motor from an idle or less essential machine. The 250 motors in the plant from ⅛ to 500 hp. include a surplus of about 10 per cent idle for auxiliary or emergency service. Practically all motors above 25 hp., except the three 100-hp., 440-volt, direct-current motors on the calender mills mentioned, are of 2,300-volt, 60-cycle, 3-phase design. These are all inspected regularly, even the ½-hp. motors.

As several of the departments, such as the *Mill Rooms*, are very dusty from powdered soapstone, the motors and bearings require frequent cleaning and inspection. Because of these conditions it was difficult to keep some of the big bearings, which were fitted for grease lubrication, from heating and burning out, due to the mixing of the dust with the grease. Now these are fitted with sight-feed oil cups which are looked after by the oiler. While they sometimes overfeed and the oil runs out the end of the bearing, they are giving much better satisfaction than the grease cups.

A record is kept of the amount of lubricating oil used over a period of six months which is compared with that of the previous six months. Other similar records of supplies are kept and checked by the maintenance department to see that the consumption does not increase unduly.

Another plan which helps check up on maintenance is used by the maintenance superintendent. The white copy of each maintenance order (Fig. 4) is filed in a folder, after the job is finished, marked with the name of the equipment whether it is a motor or machine. These are gone over periodically to see if any type of repairs are occurring too frequently. When making a repair report, the men often note that only a short time has elapsed since a similar one had been made. This record shows the date and perhaps discloses several similar repairs made within a short time previous. For example, recently we had occasion to check the life of some rawhide pinions on some of the machines. When we could show the manufacturers that one lot of pinions was lasting only from two weeks to a month while other lots were lasting a year or more, it was easy to get them replaced.

Also stuffing boxes on the calenders were blowing out too frequently. This led to installing larger boxes which take more packing and are holding up longer. This record also shows up any bearings or other parts which give so much trouble as to demand special attention. It is an important factor in keeping the maintenance costs low, through aiding in the supervision and checking because maintenance is largely a matter of proper records.

Altogether, the bonus plan works very satisfactorily since it pleases both the foreman and the company. Foremen are rewarded for thinking ahead, because to make the bonus regularly, and some of them earn full third bonus frequently, they have to consider not only doing a first-class job today at a reasonably low cost for a good job, but they also have to consider how the equipment is going to stand up in future bonus periods. The savings which have resulted from this bonus plan were estimated at 5 per cent of the total cost of production for the first year. The larger proportion of this saving was made in the *Production Departments* although the *Maintenance* and *Power Departments* contributed their share, by helping to maintain the equipment in condition for continuous operation.

Better Methods of Handling Materials

(*Continued from page* 47)

types of equipment which are installed. One such case is illustrated in this article where an elevating-platform truck skid is provided with wheels to make it "live" and chains so that it may be handled by the overhead crane. Universal equipment such as this very much increases the mobility of material-handling devices in the plant. Provisions whereby skids are interchangeable between hand-lift trucks and electric-lift trucks are always advisable where both are used in any one plant, for then the hand-lift truck can be used most economically for short movements and for "spotting" and the electric-lift trucks used for longer hauls.

Practically all manufacturers of material handling equipment are working along the one idea of simplicity in operation and reliability. In getting simplicity of operation considerable effort has been placed towards simplifying the control. One example of this is in providing push button or some similar type of remote and safe control for electric hoists.

A great deal of material-handling machinery, particularly that used for handling miscellaneous freight, is of such a nature that the most simple standard electrical equipment meets all conditions satisfactorily. In general the trend seems to be toward higher speeds, increased safety requirements and special construction to reduce maintenance.

Higher speeds mean larger power requirements and more expensive equipment, but there is always the danger of carrying this too far. For example, some operations in the handling of miscellaneous cargo probably always will require a certain amount of manual labor and in general this phase of the operation is the limiting feature. When speeds are carried to a point where the mechanical equipment has idle periods waiting for manual labor to catch up, a part of the capital investment is earning no dividends on account of the speed being higher than necessary.

Decreased maintenance resolves itself into larger wearing surfaces, decreased wheel loads, improved bearings such as ball and roller, more effective methods of keeping oil and grease from the electrical windings of machinery, totally enclosing such equipment as will stand it without overheating and similar improvements.

It is not necessary to spend $50,000 to $100,000 or more to reap benefits in material handling costs. On an expenditure of a few hundred dollars, many companies have made savings which have repaid the cost of the equipment several times within a year. In conclusion, it may be well to say that at any time when reductions in costs and increases in production are being studied, or when it is desired to put production on a more even flow of work, with schedules and a dispatching system to route it through the plant, it is well to investigate all the available methods of handling materials. One or more methods can usually be adapted to the task.

Trade Literature
You Should Know About

Readers may obtain any of this literature by writing to the address given in the item, mentioning the name and number of the literature and that it was listed in the Industrial Engineer.

Automatic and Electric Furnaces, Ltd., 173-175 Farringdon Road, London, E. C. 1—A 20-page catalog describes several types of Wild-Barfield automatic electric furnaces for the hardening of steel in connection with a magnetic detector which indicates the quenching point. Descriptions of oil and salt tempering baths, "maturing" (aging) ovens, pyrometers and a magnetic sclerometer are also included.

Sprague Electric Works of General Electric Company, 527 West Thirty-fourth Street, New York City—Construction details of Sprague safety type panel board and cabinet, Type T. P. S., are described and illustrated in folder No. 67,901. This equipment is designed for places where busbars and other live parts must be covered, but the fuse plugs left accessible.

Cleveland Armature Works, Inc., 4732 St. Clair Avenue, Cleveland, Ohio—A small folder describes the pedestal and post types of electric grinders and buffers for light work, put out by this company, which have a built-in motor operating at 3,600 r.p.m.

The Electric Motor and Engineering Company, Canton, Ohio—Catalog No. 3 (Section 4) describes the panel boards, switchboards, steel cabinets and other power equipment specialties put out by this company.

Conveyors Corporation of America, 326 West Madison Street, Chicago, Ill.—A series of folders describes the American coal-handling equipment and steam jet ash-handling conveyors put out by this company. Considerable operating and other descriptive information is contained.

Century Electric Company, 1827 Pine Street, St. Louis, Mo.—Repulsion start induction single-phase Type RS motors from ⅛ to 40 hp. are described in Bulletin No. 29. Numerous illustrations show the construction details as well as many industrial applications of this motor.

Gillis & Geoghegan, 537 West Broadway, New York City—Pamphlet No. 190 gives the results of various tests made on the G. & G. telescopic hoists for removing ashes and handling other loads between floors.

Triplex Machine Tool Corporation, 18 East Forty-first Street, New York City—A small folder describes the "Triplex," which it is claimed is a combination of a turning, milling and drilling machine. This machine is claimed to be especially advantageous where a wide variety of very accurate work is to be done, as it in itself has almost complete machine equipment and can do almost any operation on small work.

Lewellen Manufacturing Company, Columbus, Ind.—Catalog No. 15 de-describes the Lewellen variable-speed transmission, which is made in ball-bearing, self-oiling or standard type. The variation in speed in this equipment is obtained by means of a flexible belt passing over two cone pulleys, the diameters of which may be varied. Many of the industrial applications are illustrated.

Thermalene Gas Corporation, Kankakee, Ill.—A booklet describes Thermalene gas for cutting, welding and repair work. This gas is generated as it is used, from portable generators which may be taken directly to the work. The same type of welding and cutting torches are employed as are used in other gas-welding or cutting outfits.

General Electric Company, Schenectady, N. Y.—Bulletin No. 47,002, entitled "Switchboard Panels and Supporting Framework," describes the various types of switchboards under two general classifications: the vertical type and the bench type. This bulletin contains much useful information for the prospective buyers of switchboards.

Wilson Welder and Metals Company, Inc., 2 Rector Street, New York City—Catalog No. 5 describes the Wilson system of "Plastic-Arc" welding. A total of 48 pages are devoted to a description of the welding equipment and to the results which may be obtained. A large number of diagrams show the positioning of different shapes for welding.

Thompson Electric Company, 226 St. Clair Avenue, N. E., Cleveland, Ohio—Catalog B-21, entitled "Lamp Maintenance Equipment," describes the Thompson safety disconnecting hanger which is used for lowering lighting fixtures when cleaning reflectors or replacing lamps, and so eliminates scaffolding or ladders for this work.

The Emerson Electric Manufacturing Company, St. Louis, Mo.—Bulletin No. 3,156 describes the split-phase type of single-phase induction motors of 1/30 to ½ hp. In addition to the characteristics and construction of these motors, dimension diagrams are given for each size.

Condit Electrical Manufacturing Company, Boston 27, Mass.—Types D-18 and D-22 oil switches and circuit breakers are described in bulletins No. 450 and 452. These are rated up to 800 amp., 15,000 volts., or 1,200 amp., 7,500 volts.

McGill Manufacturing Company, Valparaiso, Ind.—A small folder describes the use of wall guards, to be used on stationary sockets, to prevent theft or breakage of electric lights. Six different types are illustrated.

Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa.—A booklet entitled "Synchronous Motors for Ammonia Compressor Drive," sets forth the advantages of electrically driven ice plants and shows photographs of installations in ice making and refrigerating plants, packing houses, and allied industries, particularly the ammonia compressor, and a complete line of synchronous motors that are especially adapted for this work. This line embraces a wide variety of sizes in slow speeds, for coupled or engine type drive and also, in the higher speeds, for belt drive.

Jones, MacNeal and Camp, Warsaw, Ind.—A large folder gives a detailed sectional drawing of the "Power King" electrical portable drill with two speeds, full ball bearing and oversize motors. Numbered arrows point out the special features; the numbers refer to text descriptions.

The Electric Furnace Company, Salem, Ohio—Two circulars describe the use of Baily electric furnaces for melting non-ferrous metals and also the types of electric enameling, annealing and heat treating furnaces which have been installed within the past few years.

Fairbanks, Morse and Company, Chicago, Ill.—Bulletin H-269 describes the type FH Fairbanks-Morse single-phase, ball-bearing, repulsion-start motor. Considerable attention is given to the design and construction as well as to the performance characteristics and adaptations claimed for this particular motor.

Winfield H. Smith, 10-16 Lock Street, Buffalo, N. Y.—Catalog No. 20 lists pulleys, hangers, pillow blocks and other equipment specially adapted to light power transmission machinery. Speed-reducing gears are listed for transmitting from 1/30 to 1½ hp.

Baldor Electric Company, 4351-55 Duncan Avenue, St. Louis, Mo.—A small folder describes Baldor ball-bearing, single-phase, repulsion-induction motors, from 1/6 to 5 hp., operating on 110 or 220 volts, single phase, 60 cycles, at 1,750 r.p.m.

Fred Medart Manufacturing Company, St. Louis, Mo.—Catalog S describes and illustrates the construction and a large number of the arrangements which may be made of the various types of steel shelving for different industrial uses.